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THE DEVELOPMENT OF THE KAPLAN TURBINE.

By J. R. FINNIECOME, M.Eng., M.I.Mech.E.

As the fixed-blade propeller-type turbine gives a very steep power-efficiency characteristic with a sudden peak at the most economical rating, Professor Victor Kaplan proposed, in 1912, the use of automatic adjustable runner blades in order to improve the efficiency at partial loads. The advantages of the adjustable runner blades over the fixed blades on propeller turbines were very soon realised and had it not been for the initial mechanical complications of moving the runner blades manually, or automatically, the Kaplan turbine would have been developed almost immediately on a large scale. Surprisingly little progress was made during the first 15 years and thus many years elapsed before full advantage was obtained from this novel idea. It is interesting to recall that the first commercial turbine was installed in Europe in 1925 and in America in 1928. Since then, remarkable technical advances have been made. The rapid progress was largely due to the extensive well-organised research and experimental work on actual models carried out at the hydraulic laboratories of the various universities in the world and at the manufacturers' works. Sufficient data and experience are now available to predict with remarkable accuracy the performance of full-scale runners from model tests. Units of 66,000 brake horse-power at a head of 50 ft., and running at 75 r.p.m., are now being installed, and sets of 74,000 brake horse-power are under construction.

The Kaplan turbine operates usually at a comparatively low head. It gives a high efficiency and a very flat power-efficiency characteristic and has a high characteristic speed number. Over a range of loads of 40 per cent. to 150 per cent. of the economic rating the turbine efficiency does not drop more than 5 per cent. below the maximum efficiency. It is possible to obtain an efficiency of 85 per cent. over a complete range of loads of 40 per cent. to 150 per cent. and above 90 per cent. for a variation in load of 60 per cent. to 140 per cent. of the economic rating.

Fig. 1. PELTON TURBINES

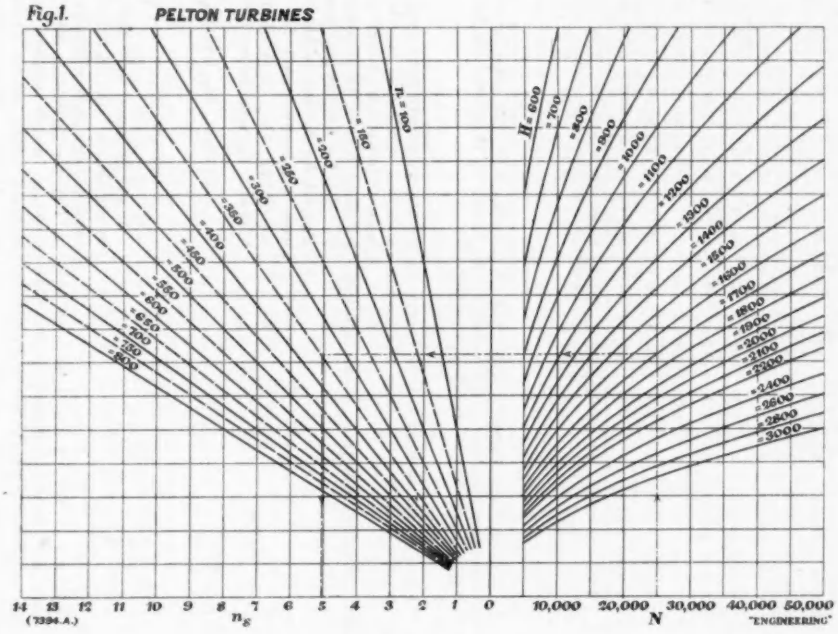
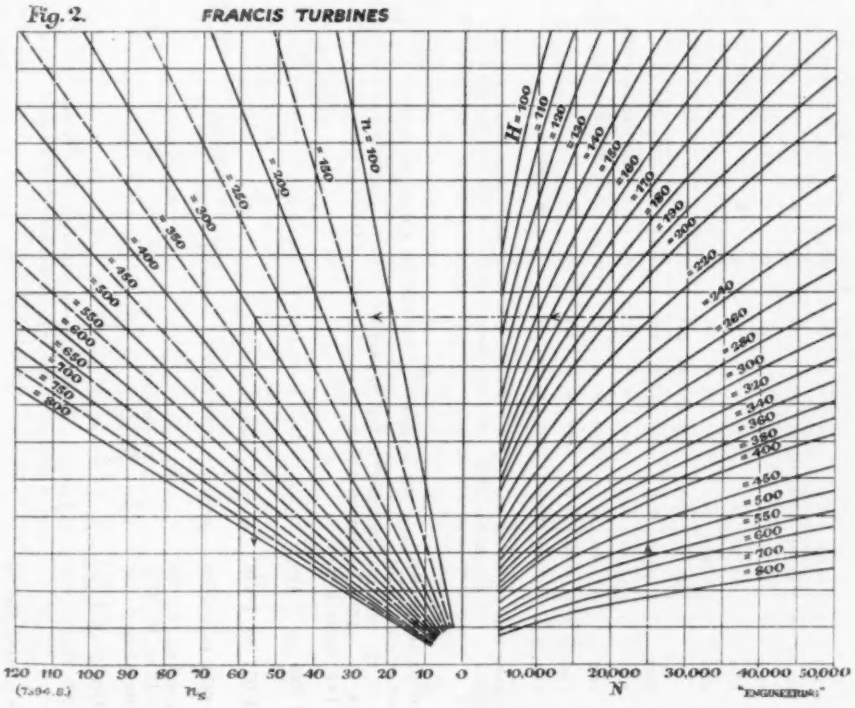


Fig. 2. FRANCIS TURBINES



A summary of the progress with propeller or Kaplan turbines is given in Table I, page 382. In this table are given the performance, particulars of the runners and design data of 18 of the largest sets installed in various countries in the world. Furthermore, Table II, page 382, gives the performance of slightly larger sets which have been installed in the United States within the last year or two. The manufacturer's name has been specially omitted from this list. The turbines are arranged in the order of the higher characteristic speed number based on English units and defined by the following well-known fundamental formula first published by Professor Camerer in 1902 :

$$n_s = n\frac{\sqrt{N}}{H^{\frac{5}{4}}} \quad . \quad . \quad . \quad (1)$$

where N = power in brake horse-power, H = effective head in feet, and n = speed of turbine in revolutions per minute.

Seeing that the characteristic speed number plays such an important part in the design of turbines, the three charts, Figs. 1, 2 and 3, on this page and on page 383, have been prepared for Pelton, Francis and propeller turbines, respectively. The charts can be used, for either metric or English units, for determining the respective numbers. However, the ratio of n_s (metric) to n_s (English) is 4·449. The approximate values of n_s for Pelton wheels is 5 to 10, for Francis turbines 10 to 80, and for propeller turbines 80 to 250. The above formula can also be expressed as a ratio of dimensions and velocities and thus we obtain a relatively simple formula for n_s.

$$n_s = 129{\cdot}3\left[1 - \left(\frac{D_1}{D_2}\right)^2\right]^{\frac{1}{2}}\left(\frac{u_2}{c_0}\right)\left(\frac{c_m}{c_0}\right)^{\frac{1}{2}} \cdot \eta_T^{\frac{1}{2}} \quad (2)$$

where D_1 = inside diameter of annulus of runner, D_2 = tip diameter of runner, u_2 = circumferential tip speed, c_0 = velocity based on theoretical head, $= \sqrt{2gH}$, c_m = mean axial velocity, and η_T = turbine efficiency. Introducing the ratio of the blade length L to the mean diameter D_m and using formula (1), a modified formula is obtained :

$$n_s = 258{\cdot}7\left(\frac{L}{D_m}\right)^{\frac{1}{2}}\left(\frac{u_m}{c_0}\right)\left(\frac{c_m}{c_0}\right)^{\frac{1}{2}} \cdot \eta_T^{\frac{1}{2}} \quad . \quad (3)$$

In order to represent graphically the various characteristic ratios indicated in formulæ (2) and (3), special charts, Figs. 4 and 5, respectively, on page 383, have been prepared. These enable the values of n_s to be evaluated from the various ratios. A typical example is shown by the dotted line on each chart.

A careful examination of Tables I and II brings out the following interesting points : (1) The Kaplan turbine with its adjustable runner blades is universally adopted in Europe and in America for heads up to 106 ft. and outputs up to 66,000 brake horse-power. (2) The fixed-blade propeller-type turbine is generally installed in Canada, although manually-operated blades have been used there for turbines up to 10,000 brake horse-power. (3) The largest turbines in operation since 1931 are at Ryburg-Schwörstadt (38,700 brake horse-power), with a maximum efficiency of 92·7 per cent. at an economic rating of 23,996 brake horse-power. (4) The largest set recently installed is at Bonneville (U.S.A.). This set develops 66,000 brake horse-power at a head of 50 ft. and a speed of 75 r.p.m., with a characteristic speed number of 144·9. (5) The turbines at Vargön (Sweden) have the largest runners (315 in. tip diameter), the largest blades (104 in.), the lowest head (14 ft.), and the highest characteristic speed number (213·5). (6) The turbines at the Shannon power station, Ireland, operate at the highest head (106 ft.). (7) The particulars and the dimension ratios of the runner (columns 11 to 19), the velocities (columns 20 to 24), the ratio of velocities (columns 26 to 28), and the ratio of the heads (column 29), are of special interest to the turbine designer. (8) The characteristic speed number in English units varies from 89·2 to 213·5. (9) The ratio of $\frac{D_1}{D_2}$ varies from 0·2810 to 0·4452. (10) The length of blade L is from 40·5 in. to 104·5 in. (11) The ratio of $\frac{L}{D_m}$ varies from 0·3839 to 0·5614. (12) The tip speed varies from 64·5 to 124·2 ft. per second. (13) The mean speed of the runner u_m varies from 43·1 to

TABLE I. RECENT INSTALLATIONS OF THE LARGEST HIGH SPECIFIC SPEED PROPELLER-TYPE WATER TURBINES IN THE WORLD.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.
Station.	Country.	Year Started Up.	No. of Sets.	Performance.						Runner.									Velocities.					h_{c_2}.	Ratios.			
				Rating. N.	Eff. Head. H.	Volume. Q.	Turbine Effiy. η_T.	Speed. n.	Spec. Speed. n_s.	Type.	Diameters. Tip. D_2.	Hub. D_1.	Mean. D_m.	Blade Length. L.	$\frac{D_1}{D_2}$	$\frac{L}{Dm}$	No. of Blades.	Material.	Tip Speed. u_2.	Mean Speed. u_m.	Mean Axial Velocity. c_m.	Theoretical Velocity. c_0.	Discharge Velocity. c_2.		Velocity. $\frac{u_2}{c_0}$.	$\frac{um}{c_0}$.	$\frac{cm}{c_0}$.	$\frac{h_{c_2}}{H}$
				H.p.	Ft.	Cub. ft. per sec.	Per cent.	R.p.m.	R.p.m.		In.	In.	In.	In.					Ft. per sec.	Ft. per sec.	Ft. per sec.	Ft. per sec.	Ft. per sec.	Ft.				
(1) Vargön*	Sweden	1934	2	15,200	14·0	11,090	86·46	46·9	213·5	K	315	106	210·5	104·5	0·3365	0·4964	4	S.S.	64·5	43·1	23·11	30·02	20·49	6·52	2·149	1·436	0·7698	0·4657
(2) Rock Island†	U.S.A.	1932	4	21,000	32·0	7,150	81·06	100	190·4	K	223	—	—	—	—	—	6	C.S.	97·3	—	—	45·40	26·36	10·79	2·143	—	—	0·3372
(3) Klingnau‡	Switzerland	1934	3	19,000	26·9	7,620	81·86	75	168·8	K	262	—	—	—	—	—	4	C.S.	85·7	—	—	41·62	20·35	6·43	2·059	—	—	0·2390
(4) Swir§	U.S.S.R.	1934	3	37,500	36·1	10,240	89·59	75	164·1	K	292	115·7	203·85	88·15	0·3963	0·4324	4	S.S.	95·5	66·7	26·12	48·22	22·02	7·53	1·981	1·383	0·5417	0·2086
(5) Laholm‖	Sweden	1932	1	16,000	28·0	5,860	86·12	83·3	163·6	K	216	86·7	151·35	64·65	0·4014	0·4272	4	S.S.	78·5	55·0	27·45	42·46	23·03	8·24	1·849	1·295	0·6464	0·2943
(6) Ryburg-Schworstadt¶	Germany Switzerland	1930-31	4	38,700	37·7	10,400	87·17	75	158·0	K	276	118	197	79	0·4275	0·4010	5	C.S.	90·3	64·5	30·63	49·27	25·03	9·73	1·833	1·309	0·6217	0·2581
(7) Albbruck-Dogern**	Germany Switzerland	1934	3	37,600	37·7	10,600	83·10	75	155·7	K	276	118	197	79	0·4275	0·4010	5	C.S.	90·3	64·5	31·22	49·27	25·51	10·11	1·833	1·309	0·6336	0·2682
(8) Great Falls††	Canada	1932	6	28,000	56·0	5,000	88·31	138·5	151·3	F.B.	189·5	53·25	121·375	68·125	0·2810	0·5614	6	C.S.	114·5	73·3	27·72	60·05	25·53	10·12	1·907	1·221	0·4616	0·1807
(9) Safe Harbour‡‡	U.S.A.	1932-34	6	42,500	55·0	8,000	85·30	109·1	150·2	K	220	86·5	153·25	66·75	0·3932	0·4356	5	C.S.	104·7	72·9	35·85	59·52	30·30	14·26	1·759	1·225	0·6023	0·2593
(10) Munkfors§§	Sweden	1931	2	15,000	51·0	3,130	82·99	167	150·1	K	146	65·0	105·5	40·5	0·4452	0·3839	4	S.S.	106·4	76·9	33·58	57·31	26·92	11·26	1·857	1·342	0·5859	0·2208
(11) Lilla Edet‖‖	Sweden	1926	3	11,200	21·3	5,155	90·08	62·5	144·5	K	228	92·5	160·25	67·75	0·4057	0·4228	4	C.S.	62·2	43·7	21·76	37·04	18·18	5·13	1·679	1·180	0·5875	0·2409
(12) Seven Sisters††	Canada	1932	3	37,500	66·0	5,700	88·02	138·5	142·6	F.B.	195	67	131	64	0·3436	0·4886	6	C.S.	117·8	79·1	31·16	65·20	27·48	11·73	1·807	1·213	0·4779	0·1777
(13) Groenfalls††	Norway	—	2	18,200	74·5	2,670	80·80	214	131·9	K	133	—	—	—	—	—	4	S.C.S.	124·2	—	—	69·26	27·67	11·89	1·793	—	—	0·1596
(14) La Gabelle (Quebec)†††	Canada	1932	5	32,000	60·0	5,400	87·21	120	128·5	F.B.	195	67	131	64	0·3436	0·4886	6	C.S.	102·1	68·6	29·52	62·16	26·04	10·53	1·643	1·104	0·4749	0·1755
(15) Island Falls††	Canada	1931	3	14,000	56·0	2,500	88·31	163·6	126·3	F.B.	139	42·25	90·625	48·375	0·3040	0·5338	6	C.S.	99·2	64·7	26·14	60·05	23·72	8·74	1·652	1·077	0·4353	0·1561
(16) Kembs¶¶	France	1932	5	36,600	54·0	6,600	90·69	93·7	122·5	F.B.	221	98·4	159·7	61·3	0·4452	0·3839	6	C.S.	90·3	65·3	30·90	58·97	24·78	9·54	1·531	1·107	0·5240	0·1767
(17) Wettingen***	Switzerland	1933	3	10,700	76·0	1,412	88·06	214	98·7	K	114	—	—	—	—	—	6	C.S.	106·4	—	—	69·96	19·92	6·16	1·521	—	—	0·0810
(18) Shannon†††	Ireland	1934	1	33,000	106·0	3,040	90·45	167	89·2	K	137·5	—	—	—	—	—	7	S.S.	114·7	—	—	82·61	22·47	7·84	1·389	—	—	0·0740

* *The Engineer*, November 17, 1934. † *Power Plant Engineering*, May 1, 1932. ‡ *Bulletin*, November 23, 1934. § *The Engineer*, July 8, 1932. ‖ World Power Conference, 1933. ¶ *Z.V.d.I.*, September 19, 1931; *Schweizerische Bauzeitung*, May 21, 1932.
** *Siemens-Schuckert Zeitschrift*, May 27, 1933. †† *Power*, January, 1933. ‡‡ *Power*, March 15, 1932. §§ *The Engineer*, May 20, 1927. World Power Conference, 1933. ‖‖ *The Engineer*, May 20, 1927. ¶¶ *Schweizerische Bauzeitung*, December 24, 1932.
*** *Schweizerische Bauzeitung*, vol. 103, page 224 (1934). ††† *Elec. Review*, February 9, 1934. *Siemens-Schuckert Zeitschrift*, September, 1934.

79·1 ft. per second. (14) The mean axial velocity c_m varies from 21·76 to 35·85 ft. per second. (15) The theoretical velocity c_0 based on the effective head varies from 30·02 to 69·96 ft. (16) The discharge velocity c_2 varies from 18·18 ft. to 30·30 ft. (17) The ratio $\frac{u_2}{c_0}$ varies from 1·389 to 2·149. (18) The ratio $\frac{u_m}{c_0}$ varies from 1·077 to 1·436. (19) The ratio $\frac{c_m}{c_0}$ varies from 0·4353 to 0·7698. (20) The discharge head corresponding to the discharge velocity c_2 varies from 5·13 to 14·26 ft. (21) The ratio of the head corresponding to the discharge velocity c_2 to the effective head $\left(\frac{h_{c_2}}{H}\right)$ varies from 0·0740 to 0·4657. (22) The number of blades varies from 4 to 7.

The velocity ratio $\frac{u}{c_0}$ and $\frac{c_m}{c_0}$ are plotted for the characteristic speed number n_s in Figs. 6 and 7, and the ratio of $\frac{D_1}{D_2}$ for various values of n_s are indicated in Fig. 8, page 384. The tip diameter as a function of the ratio of the volume Q to the speed of the turbine n for the various sets is graphically presented in Fig. 9, page 384. From these design points the following formula has been derived :—

$$D_2 = 55 \sqrt[3]{\frac{Q}{n}} \quad . \quad . \quad . \quad (4)$$

where D_2 = tip diameter in inches, Q = volume in cub. ft. per second, and n = speed of the turbine in r.p.m.

The values obtained from this formula are indicated by curve *a*. It will be found that for the Vargön runner this value is slightly lower than curve *a*. This is primarily due to the exceptionally high discharge velocity relative to the very low effective head; otherwise curve *a* fits the actual points extremely well over such a wide range of volumes, heads and speeds. To this curve *a* has been added graphs *b* and *c*, which represent values for the economic tip diameter proposed by Ahlfors, in 1926, for Francis and propeller turbines, and by Pantall, for Kaplan turbines, in 1933. The formulæ were originally given for metric units, but by converting the constant for English units the following expressions are obtained :—

$$\text{Ahlfors}: \quad D_2 = 52{\cdot}8 \sqrt[3]{\frac{Q}{n}} \quad \text{(curve } b\text{)} \quad . \quad (5)$$

$$\text{Pantall}: \quad D_2 = 64{\cdot}2 \sqrt[3]{\frac{Q}{n}} \quad \text{(curve } c\text{)} \quad . \quad (6)$$

It will be found that Ahlfors values are very close to the design data on actual Kaplan and propeller turbines, although originally this formula was based on Francis turbines. Strange to say, the Pantall formula, which applies particularly to Kaplan turbines, gives values about 20 per cent. higher than Ahlfors. It is worth while to mention here that, in 1937, C. Keller derived a formula for the

TABLE II.

1.	2.	3.	4.	5.	6.	7.	8.
Item.	Power Station.	Year Started Up.	Rating. B.h.p.	Effective Head. Ft.	Speed of Turbine. R.p.m.	n_s.	Type.
1	Wheeler Dam	1936	45,000	48·0	85·7	143·8	F.B.
2	Bonneville	1937	66,000	50·0	75·0	144·9	K.
3	Pickwick	1939	55,000	47·0	81·8	155·9	K.

THE DEVELOPMENT OF KAPLAN TURBINES.

Fig. 3. PROPELLER & KAPLAN TURBINES

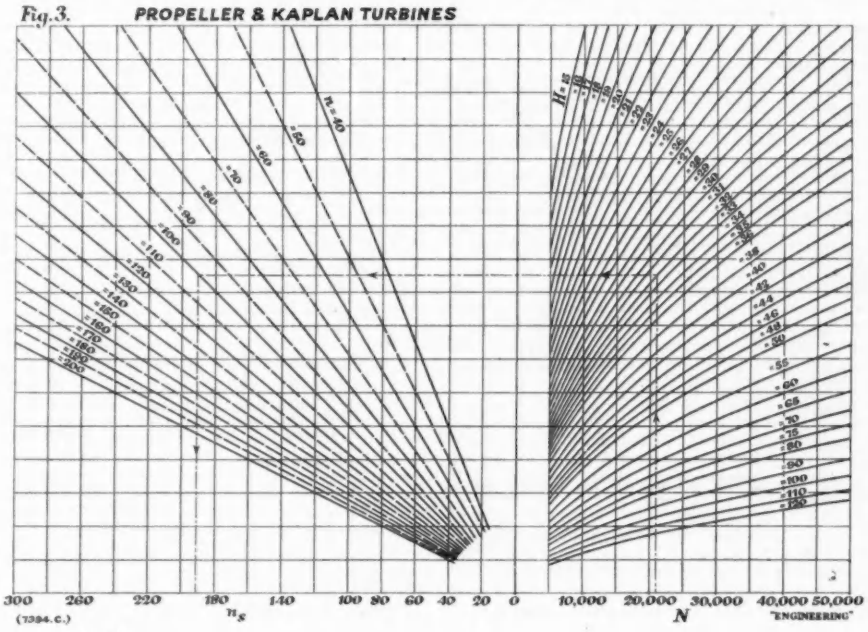


Fig. 4.

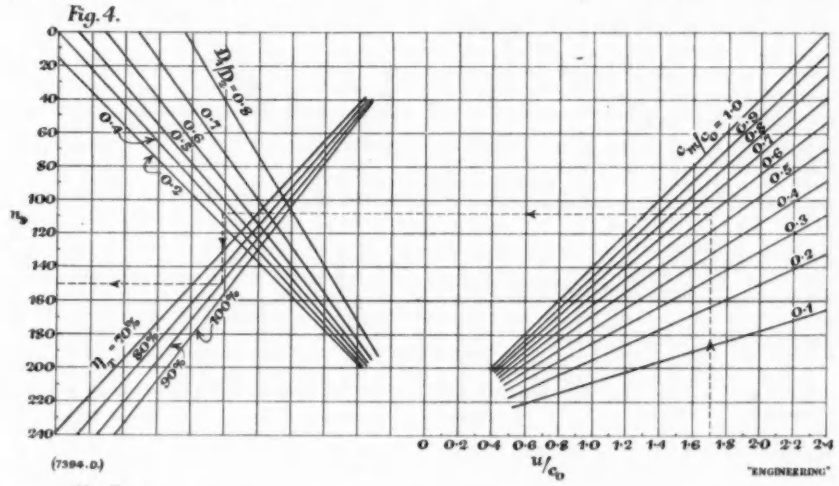
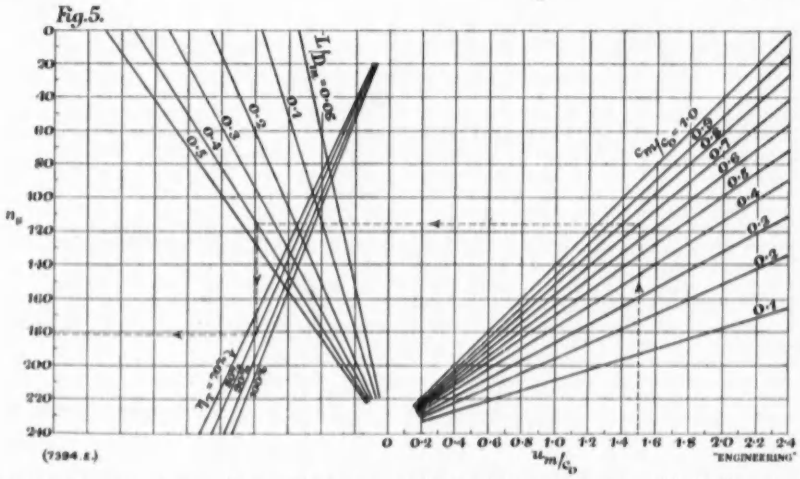


Fig. 5.



economic tip diameter of propeller turbines based on aerodynamic theory. It is a little more complicated than the previous formulæ for it incorporates additional design factors, such as head, the ratio of the drag to lift coefficient, the effect of the suction loss, and the ratio of the outside diameter to the inside diameter of the runner. It must be borne in mind that Keller's formula has not been investigated further for these particular turbines as the simple formula (4) checks up admirably with the data presented in Table I. Moreover, the additional design data to enable Keller's formula to be applied are not available.

As stated previously, another point of interest is the determination of the full-scale efficiency from experimental data on models. Two well-known formulæ are generally applied. They are entirely different in character, and are known as :—

(*a*) The Camerer formula—

$$\eta_T = 1 - (1 - \eta_0)\left[\frac{1{\cdot}4\sqrt{d_0} + \sqrt{K_d}}{1{\cdot}4\sqrt{d_0} + 1}\right]. \quad (7)$$

(*b*) The Moody formula—

$$\eta_T = 1 - (1 - \eta_0)\,[K_d{}^{\frac{1}{5}} \,.\, K_h{}^{\frac{1}{10}}] \quad . \quad . \quad (8)$$

where D = tip diameter of full-scale turbine, d_0 = tip diameter of model turbine, H = head of actual runner, h_0 = head of model runner, η_T = turbine efficiency of full-scale turbine, η_0 = turbine efficiency of actual model turbine, $K_d = \frac{d_0}{D}$ and $K_h = \frac{h_0}{H}$.

It will be observed that a notable feature of the chart, Fig. 10, page 384, is that both Camerer and Moody full-scale efficiency can be determined with a minimum amount of mathematical work. A typical example is indicated in this chart to demonstrate its usefulness. By following the chain-dotted line, the Camerer efficiency can be obtained, and from the dotted line the Moody value. The difference in efficiency for the full-scale model using the Camerer and Moody formula is also clearly shown. This particular chart is of special interest to turbine designers and to research engineers for it enables them to assess quickly the relative values of this full-scale efficiency by both formulæ.

In conclusion, the main object of this article has been to analyse and co-relate the essential data and experimental facts of propeller and Kaplan turbines referring specifically to design factors based on large units installed in various parts of the world and supplied by the principal manufacturers in Europe and America. Furthermore, a new formula was derived from the data showing the relationship of the economic tip diameter and the ratio of the volume to the speed of the turbine. Finally, the chart Fig. 10 shows that in all cases the Moody formula gives full-scale efficiencies higher than Camerer's values.

LITERATURE.

The Design of High-Pressure Plant and the Properties of Fluids at High Pressures. By DR. D. M. NEWITT. London: Oxford University Press (Sir Humphrey Milford). [Price 35*s.* net.]

THE properties of matter under conditions of high pressure have interested physicists for many years. During the early part of the Nineteenth Century, many workers investigated the compressibility of fluids, but their results were inaccurate because of the difficulty of measurement of high pressures, and of making proper allowance for the distortion of containing vessels which were made of materials with a low yield point. This early work, however, served a most useful purpose in developing experimental methods, and led to the classical researches of Amagat, Natterer, Cailletet, Regnault, Tammann, and others, some of whom worked at pressures as high as 3,500 atmospheres. With the increase in knowledge of the behaviour of materials under high stress, and the availability of alloy steels, physicists, of late years, have been able to work with confidence and with great accuracy at pressures far higher than at one time seemed practicable. For example, Bridgman's ingenious method of obturation of pressure joints, and of pressure measurement, enabled him to work at pressures as high as 20,000 atmospheres, by the use of special alloy steels.

Dr. Newitt has had long experience in high-pressure work, and the present book is a welcome addition to the literature of the subject. It follows closely on the lines of Bridgman's well-known work, *The Physics of High Pressure*, inasmuch as the first part, about a quarter of the whole, deals with the principles of design and the construction of experimental high-pressure apparatus and the remainder with the properties of fluids at high pressure. Part I, which deals with experimental plant design, includes a brief description of the properties of materials used for high-pressure work ; a chapter on the care and use of cylinders for the storage and transport of gases ; a notably well-written section on the strength of cylinders, including a theoretical discussion of wire-wound cylinders, compound-cylinders formed by shrinkage, and the use of autofrettage ; and the effect of temperature gradients on the stresses set up in the walls of high-pressure

vessels. Then follow detailed notes on the design of plant and accessories, including valves, pipework and fittings, small compressors and hydraulic pumps, and the safety precautions necessary in the operation of high-pressure apparatus. A chapter is devoted to the important subject of the measurement of high pressures, and both primary and secondary gauges are fully described and well illustrated by diagrams.

Part II of the book gives a comprehensive survey of the present state of knowledge of the properties of fluids at high pressure, including the pressure-volume relationships of gases and liquids, the equation of state problem, and the influence of pressure upon viscosity, solubility and refractivity. A valuable feature of this section is the inclusion of details, with line diagrams, of the experimental apparatus used. In Part II there are also two interesting chapters on the compression and circulation of gases at high pressure and the liquefaction of gases. The former deals with the subject from the theoretical aspect, and is followed by a discussion of the influence of pressure on the viscosity of gases. The latter describes in detail the principles of the Linde, Claude, and Heylandt liquefiers, and the application of the Linde principle to the liquefaction of hydrogen and helium.

Each chapter of the book is concluded by a bibliography, and there is an appendix dealing with the thermodynamic properties of various gases, the values of the Joule-Thomson coefficient for nitrogen, air, and argon, and the refractive index of carbon dioxide at various pressures. There is an author index and a subject index; but the latter could have been much improved. The publishers are to be congratulated upon the production generally, especially in view of war-time difficulties. Although it is written for the specialist, all who are interested in high-pressure technique will find much useful information in this book.

Technical Drafting. By Professor Charles H. Schumann. New York and London: Harper and Brothers. [Price 3.50 dols.]

The universal language of the drawing and the freehand sketch, which is the birthright of engineers the world over, resembles spoken languages in having sundry dialects, and it cannot yet be said that a manual of machine drawing designed for one country is exactly applicable to the needs of another. The differences between English and American practice, however, are not so wide that the English "draughtsman" cannot study this book on American "drafting" with interest and, probably, with profit; more especially as some English engineering firms have employed the "third-angle projection," favoured in America, for many years past. Such minor details of terminology as "triangles" and "thumb tacks," for set squares and drawing pins, do not present any difficulty in interpretation, when the first novelty has passed.

The fact that the book is intended to cover a college course arranged for the use of architectural (that is to say, structural) students as well as for those studying civil, mechanical and electrical engineering, and is designed to be of service to them as a work of reference in their subsequent careers, has enabled the author to plan it upon more spacious lines than characterise most text-books on drawing-office practice. It is divided into two parts, the first of which comprises a complete elementary course, with examples and test problems, covering not only the customary descriptions of equipment, geometrical constructions, he general theory of graphic representation, and the intersection and development of surfaces, but also chapters on perspective and the various methods of pictorial drawing, lettering, sketching, and machine design.

Part II, dealing with "Professional Drafting," differs from most treatises of the kind with which we are acquainted, in the lavish use that is made, for purposes of illustration and exposition, of actual designs reproduced by the collaboration of some 70 engineering firms, State departments and technical institutions and periodicals. Although this method has the disadvantage that many of the examples, sooner or later, must become "dated," it affords a direct insight into current practice that is likely to remain of considerable value at least for a number of years; and the majority of the designs will retain this value for instructional and reference purposes, even though developing practice may call for amending notes in future editions. The book is admirably produced, and the illustrations, in particular, are deserving of the highest praise.

THE DEVELOPMENT OF KAPLAN TURBINES.

(*For Description, see page* 381.)

Fig. 6.

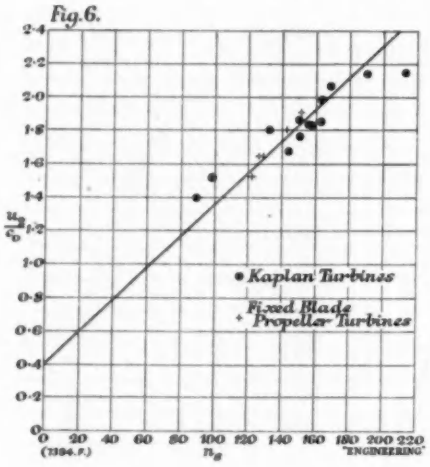


Fig. 8.

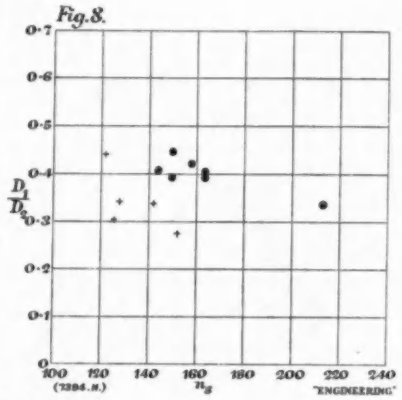


Fig. 7.

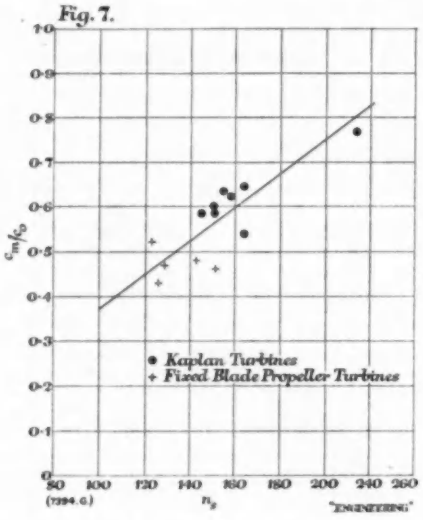


Fig. 9.

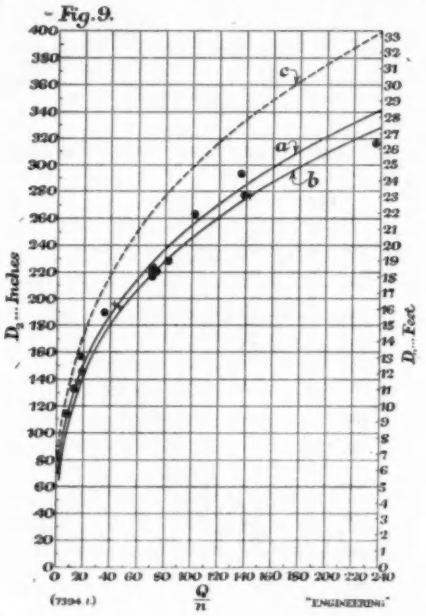
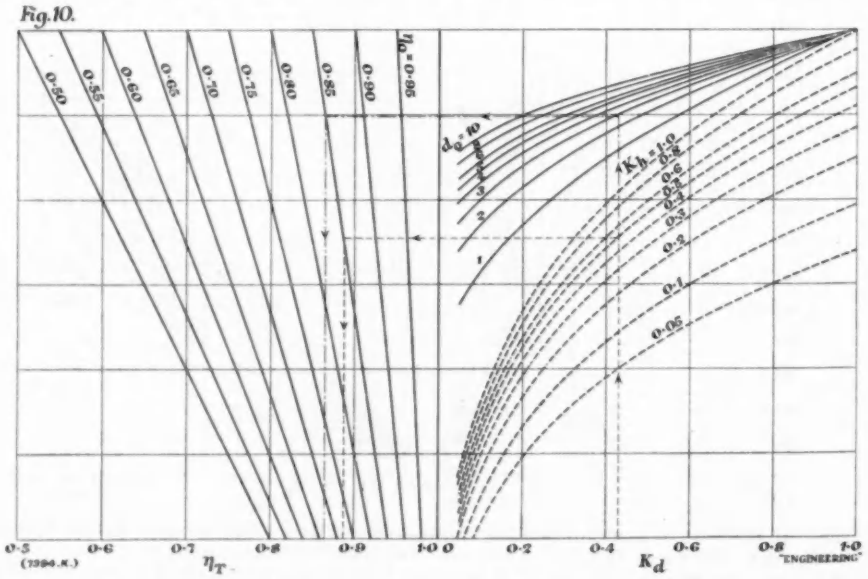


Fig. 10.



Blast-Furnace at Jamshedpur, India.—A brief description of a new blast-furnace, designed and equipped in accordance with modern practice in the United States, and recently erected at the Jamshedpur Works of the Tata Iron and Steel Company, Limited, is contained in an article by Mr. E. T. Warren, in a recent issue of the *Blast Furnace and Steel Plant*. The furnace has a volume of 35,160 cub. ft., and is capable of producing 1,100 tons of pig iron a day.

O.M.T. OPTICAL FLATS.

THE presence of coloured rings or bands in the space between two transparent surfaces in very close proximity and on which white light is falling has been familiar since the days of Newton. The phenomenon is due to interference between the light waves reflected from the two closely adjacent surfaces. The well-known Newton's rings are produced when a convex lens is pressed on to a glass plate, and if two glass plates which are nominally flat are pressed together the "rings" will take the form of contours which serve to indicate the surface irregularities. Assuming that one surface is perfectly flat, the high parts of the other surface will produce wide bands and vice versa; generally, the wider the bands the closer the contact. The coloured bands only appear if the experiment is made with white light. If monochromatic light be used instead of white light, the coloured bands will be replaced by bands of light and shade, and if the wavelength of the monochromatic light be known it is possible to determine the actual thickness of the air film between any part of the reflecting surfaces by measuring the spacing of the interference bands at the part in question. In this way it is possible to test the flatness of any reflecting surface, whether of transparent material or not, by placing over it a piece of transparent material which has been made optically flat and noting the spacing of the interference bands produced. Modern precision work in engineering often requires the production of surfaces which are so accurately flat that the measurement of any irregularities is only possible by the interference method briefly referred to above, and optical flats for this purpose are now being made by Messrs. Optical Measuring Tools, Limited, Slough, and distributed by Messrs. E. H. Jones (Machine Tools), Limited, Edgware-road, The Hyde, London, N.W.9. We give below an account of the manufacture and use of these optical flats.

If a perfectly flat testing surface is imposed on a curved one, curved interference rings will appear. Anywhere on the innermost ring, *i.e.*, that near the point of contact, the air space between the two surfaces will have a thickness equal to half the wavelength of the light used, *i.e.*, of the order of 0·00001 in. At the second ring, the thickness will be equal to one wavelength, at the third equal to 1·5 wavelengths, so that the number of bands in a given length, multiplied by 0·00001, will give the thickness at the deep end of the wedge of air, or, in other words, the total departure of the surface being tested from a true plane. The distance between successive fringes is also important; thus, with a spherical surface, which slopes more steeply outwards from the central contact point, the interference bands would appear wide at the centre and would become increasingly closer together with increasing distance from the centre. If there were, say, 5 bands visible, the height of the spherical segment bounded by the outermost band would be 0·00005 in. The application of an optical flat to a flat but sloping surface, would indicate by the parallel and equidistant interference bands that the surface sloped uniformly over the distance covered by the bands. Thus, if the distance between two bands was 1 in., the surfaces would diverge by 0·00001 in. in that distance. If in the next $\frac{1}{2}$ in. the bands were closer together a still steeper slope from that point is indicated. No further comment on this quantitative property is called for at the moment but it may be observed that in measuring the space between the bands the distance between the dark centre of each should be taken, or that between the edges of the red colour nearest the centre of the fringe when ordinary white light is used.

The construction of the O.M.T. optical flats may now be considered, some of the manufacturing operations being illustrated in Figs. 1 to 8, Plate XXVII; Figs. 9 to 14, on page 390, show some typical arrangements of interference bands. In the first place, it should be noted that the material from which the optical flats are made is quartz, a native mineral occurring in crystals very often hexagonal in cross-section and both transparent and colourless. Quartz, as is well known, is very hard, its hardness, taking that of the diamond as 10, being 7, and it will, therefore, readily scratch most glass. This high degree of hardness, it is obvious, conduces to long life, which is also increased by the rather curious feature possessed by quartz, viz., that a furrow caused by a scratch on it is not accompanied by the ridges which are produced by a scratch on glass. The quartz flats can be thus used until the surface is virtually opaque from scratches, though one scratch only on a glass flat will necessitate re-grinding and re-polishing.

Reference to Fig. 1 will show, in the background, specimens of the raw material, though more characteristic crystals are seen in Figs. 2 and 3. The operation shown in Fig. 2 is the removal of the pyramidal ends of the crystal by means of a circular saw of Swedish iron. The disc is 18 in. in diameter and is serrated on its periphery, these serrations being charged with diamond dust. The crystal is held in a vice, which is pivoted so that it can swing on either side of a vertical axis. The crystal can, therefore, be fed on to the rotating saw, a uniform feed pressure being obtained by a weight-loaded wire attached to the arm of the vice. The feed movement is controlled by a handwheel and screw so that, although the pressure is constant, the rate of advance may be regulated. The operator's right hand in Fig. 2 is shown grasping the handwheel. The crystal, after the end has been sawn off, is ground square with the optical axis of the quartz, this operation being illustrated in Fig. 3. A rotating cast-iron table charged with abrasive is used for this process. In most cases, the crystals have to be cut at both ends and the surfaces ground and polished, so that they can be examined for internal defects. A crystal so treated is seen in Fig. 4, under examination in an optical cabinet.

The saw is, of course, also used for cutting up the crystal into suitable discs for the different types of flats seen in Fig. 1, an operation requiring considerable judgment to avoid waste. Thus, the crystal on the right in Fig. 1 has been sawn longitudinally so that its cross-section is approximately rectangular. Transverse cuts then divide the piece into rough blocks, one of which is seen in the foreground on the right in Fig. 1. The discs are rough ground on abrasive machines similar to that shown in Fig. 3, the time required for grinding each side ranging from 15 minutes to 30 minutes. It is possible to finish the two faces to within 0·01 in. from true parallelism, a degree of accuracy which reduces the time required for the subsequent polishing operations. Surplus material is removed from the edges of the discs by shearing to approximate final form, after which the edge is ground to shape. For the circular flats this is done by attaching the disc to a face plate by means of pitch. The face plate is then rotated with the periphery of the disc in contact with the periphery of a rotating lap charged with diamond dust. The edges of the discs do not need the polishing operations required for the working faces.

The polishing operations consist of a series of lapping processes, the number of which depends on the degree of finish required. In this connection it is necessary to distinguish between the two parts played by pitch in the several operations. In the first place, pitch is used to hold the flats in place while their surfaces are polished, cast-iron lapping discs with abrasives of different degrees of fineness applied being used. Secondly, a pitch surface loaded with abrasive is used for hand-finishing certain types of flat. In the first case, the absolute truth of the pitch surface is not of importance, since the flats are partly embedded in it with their upper surfaces clear. In the second case, however, it is necessary for the pitch surface to be truly flat, and the method of securing this condition is illustrated in Fig. 5. An accurately flat steel disc held in the hand and warmed prior to use is employed for truing the pitch surface, which is formed on a stationary table. These steel discs are themselves trued by the method shown in Fig. 6. A rotating cast-iron disc loaded with abrasive, seen near the operator's hands, is used, the truing disc being traversed mechanically backwards and forwards across the grinding disc by means of the variable crank mechanism seen on the right. The crank is rotated by belt from a pulley on the grinding-disc spindle. The truing disc is held at the end of a lever and is free to rotate; it is kept in contact with the grinding disc by its own weight.

These two illustrations may apparently break the continuity of the account, since the next logical step in the description, after the cutting-off and edge finishing of the rough flats, is the preliminary polishing. Machines similar to that shown in Fig. 6 are, however, also used for the first stages of polishing the flats. What corresponds to the rotating grinding disc, in the preliminary lapping, is a plate faced with pitch in which the flats are embedded, and the truing plate is replaced by a lapping disc which is loaded by a cylindrical weight of about 6 lb. on the spindle. The final stages of polishing are done on lapping machines of a generally similar principle but differing in detail. Three of these machines are shown in operation in Fig. 7. The tables, of course, rotate and the lapping discs are traversed by a crank arm, the direction of reciprocation of the laps being, however, from side to side and not backwards and forwards. A number of flats are dealt with at a time, two of the table load being visible in the centre machine in Fig. 7. The table speed range is from 29 r.p.m. to 100 r.p.m. According to the particular work being done and the powdered abrasive employed, increases are made in the fineness at each successive operation, of which four or more may be required, jewellers' rouge being employed in the final stage. Generally speaking, each face of a flat requires lapping for about 8 hours.

The flat has, of course, to be reversed on its table and the polished surface of the side first treated is used as a datum for determining the thickness of the flat and the parallelism of the remaining side. The degree of accuracy obtained may be gathered from the fact that the working surfaces of the rectangular flats seen in the case on the right in Fig. 1 are accurate to within 0·000002 in., that is, to within two-millionths of an inch. The flats in this set of four measure 2 in. by $1\frac{1}{2}$ in. by $\frac{1}{4}$ in., and are suitable for checking the parallelism, flatness and lengths of gauges or other accurate work. For more general use, a set of three circular flats, $2\frac{1}{4}$ in. in diameter by $\frac{7}{16}$ in. thick, is supplied, the working surfaces being both parallel and flat to within 0·000002 in. But, for one purpose at least, viz., the checking of micrometers, an even higher degree of accuracy is required. The surfaces of these special discs must be flat to within the amount of separation producing a single interference band and the distance apart of their two surfaces must be kept within close limits. Accurate control of the thickness of the flats is not always readily obtained on the lapping machines, so that the hand-finishing process, which is a highly-skilled operation and is illustrated in Fig. 8, is employed. In this, a cast-iron plate covered with pitch carrying abrasive is used, and the flats are rubbed down on the surface by hand, as shown. The treated pitch surface is itself trued at frequent intervals by means of the smooth and level steel disc seen near the right hand of the operator in Fig. 8 and shown in use in Fig. 5.

This hand finishing process is employed in the production of the set of five flats seen on the left in Fig. 1. With them it is possible to check the flatness and parallelism of the anvils of a micrometer and to check the accuracy of its vernier scale. The several flats of the set are 1 in., 0·5 in., 0·5062 in., 0·5124 in., and 0·5186 in. thick. For parallelism and flatness they are accurate to 0·00002 in. and 0·00001 in., respectively. The thicknesses stated are the nominal sizes engraved on the flats, but a working tolerance of $\pm$ 0·0003 in. is allowed. The flatness of the micrometer anvils is checked by the insertion of one of the smaller flats between them, the resultant bands indicating any irregularity. When the anvils are advanced into contact with each side of the flat, parallelism, or want of it, will be evident from the similarity or difference in the bands on each face. Checking the zero reading does not require the use of a flat but the several thicknesses of the flats will enable unit and fractional readings of the micrometer scale to be checked. The single circular flat seen in the centre of Fig. 1 is for use as a master or reference flat for checking the standard flats for wear or accuracy. It is $2\frac{1}{4}$ in. in diameter by $\frac{7}{16}$ in. thick and, since it is manufactured to a tolerance of 0·000001 in., viz., one-millionth of an inch, is twice as accurate as the standard flats.

The uses of optical flats generally do not require detailed description, but it will be obvious that the now widely-used measuring blocks can be effectively checked by such means. Further, numerous other applications occur in different fields. Thus, if a minute deflection of a loaded structure, such as a machine bed, is to be determined, an optical flat carried in an independent structure can be placed in close contact with a prepared part of, say, the bed, and should show even coloration before the load is applied. Any deflection, both in extent and direction, will be shown, on application of the load, by the appearance of interference bands when separation of the two surfaces occurs. The photographs reproduced in Figs. 9 to 14, page 390, show typical interference bands. It should be explained that these photographs were taken specially for illustration purposes and the bands in some cases are, therefore, somewhat, exaggerated. They were made by the contact of a $2\frac{1}{4}$-in. circular standard flat, having surfaces flat to within two-millionths of an inch, and pieces of polished glass shaped to give the desired effect. Monochromatic light was employed, and glass was used for the tested surface in order to make the bands more clear for photographic purposes.

The surface tested in Fig. 9 is spherical, as the interference-bands are similar to the well-known Newton rings obtained with a convex lens and a flat plate. The greater width between the bands towards the centre indicates that the surface is closer there than towards the outside, therefore, it is convex. A concave surface would also show rings but they would be conversely distributed. Pressure of a finger at the edge of the flat on a convex surface would cause rocking of the flat and the centre of the rings would move to the new point of contact. The surface in this instance is not truly spherical as the rings are not symmetrical. The rings seen in Fig. 10 indicate that the surface has either a convexity or concavity near the right-hand edge. Pressure with a finger tip on the flat at this point will distinguish which of these conditions exists. If the interference bands move towards the point of pressure a hollow is indicated, if away from the point of pressure there is a protuberance. The bands seen in Figs. 11 and 12 both indicate irregular contact. It is evident that, in Fig. 11, contact across the diameter is close, as the inner interference band is wide. The edges are, however, out of truth in varying degrees. The surface under examination in Fig. 12 is still more irregular, and a ridge or valley may exist along the centre line; finger-tip pressure on the flat will indicate which. The

equidistant and parallel bands seen in Fig. 13 indicate that the surface under examination is flat but that one edge of the flat is higher than the other; that is to say, there is a wedge of air between the surfaces. The amount of slope may be determined by counting the number of bands per inch as already indicated. The tilting of the plate may be due to a particle of dust at one end and if this is removed and the plate pressed or "slid" into close contact, the interference bands will vanish and the more or less continuous sheet of colour indicated in Fig. 14 will be obtained.

The manipulation of the testing flats and the interpretation of the results naturally requires a little practice, but beyond this no special skill or training is needed. As regards manipulation, it is necessary to ensure that both the flat and the surface tested are perfectly clean and free from grease, while, as regards interpretation, it may be remembered that the interference bands present some of the characteristics of a contour map of the surface tested.

SPAR-BOOM HORIZONTAL MILLING MACHINES.

THE horizontal milling machines illustrated in Figs. 1 to 4, on this and the opposite pages, have been designed for the special purpose of milling aluminium-alloy aeroplane spars of flat, Tee, or channel cross-section, or double-channel cross-section, the latter term denoting spars with two parallel grooves. It will be seen from Fig. 1, which shows a single-headed machine, and from Figs. 3 and 4, which show a double-headed machine, that the milling head is traversed along a fixed bed, the maximum length of traverse in both cases being 27 ft. The cutter is 9 in. in diameter, and has a transverse adjustment of 3 in. and a vertical adjustment of 4 in. The single-headed machine is made in two types, of which, the simplest, shown in Fig. 1, is intended for milling spars of flat or tee cross-section, the spiral or taper portions being dealt with by setting the spar over in the jigs. The second type is designed for milling the channel and double-channel sections referred to above and is provided with vertical "in-feed" to the cutter. The taper portion of the spar, or the feeding-in to depth, is controlled by a cam bar bolted to the work fixture base. A roller, in contact with the underside of this bar, is attached to the cutter head so that the cutter is drawn downwards into the cut, a coil spring ensuring contact between the cam and bar. The double-headed machine is designed to handle flat or tee-section spars, of which the spiral or taper portions on one side are formed by setting the spar over in a jig and on the other side by automatic "in-feed" of the cutter spindle. It will thus be realised that the three machines will suit different conditions. All are known as the Wickman-Holroyd spar-boom horizontal milling machines, and are supplied by Messrs. A. C. Wickman, Limited, Coventry.

The double-headed machine, of which the heads are shown in Fig. 2, merits, perhaps, the most detailed attention but much of its construction applies also to the single-headed machines. Referring to the drawings, Figs. 3 and 4, it will be seen that the machine consists of a heavy bed of two ways, on which the cutter saddles are traversed, and having a slotted and tenoned work table, 12 in. wide by 30 ft. long, between the ways. The saddle *a* carries a fixed head, and saddle *b* a swivel "in-feed" head. Both saddles are formed with a vertical column carrying the sliding spindle head. In saddle *a*, the column and saddle proper are integral, but in saddle *b* the column is arranged to swivel on the saddle in order to maintain the cutter face parallel to the angle appropriate to the required "in-feed." The "in-feed" head has a compound slide, as shown in Fig. 2, this arrangement providing both vertical adjustment and "in-feed," the latter being obtained by a cam bar bolted to the side of the bed. The cam bar is indicated at *c* in Fig. 4, and is adjustable with a locking device. The ratio between the cam and cutter is 10 to 1, so that maximum accuracy is ensured. The spindle of both heads runs in a quill for transverse adjustment, the range of adjustment being between a minimum of $2\frac{3}{8}$ in. and a maximum of $5\frac{3}{8}$ in., these measurements being from the spindle nose to the centre of the table. The vertical adjustment lies between a minimum of 8 in. and a maximum of 12 in., measured from the centre of the spindles to the top of the work table. The vertical adjustment is effected by a handwheel and the transverse adjustment by a star wheel, both wheels being readily distinguishable in Fig. 2, and having micrometer dials. Efficient locking devices are provided to both movements.

Each spindle is driven, through multiple Vee-belts, by a $7\frac{1}{2}$-h.p. motor running at 975 r.p.m. No provision for change in spindle speed is necessary, but belt-tensioning equipment is provided. The spindles are of high-carbon steel, mounted in taper-roller bearings. The noses are of the British Standard nominal size of $3\frac{1}{2}$ in., with a hole tapered $3\frac{1}{4}$ in. to the foot. The saddles are traversed by screw and nut, the screws being rotated, through Vee-belts and variable speed gear, by a 2-h.p. motor running at 1,425 r.p.m., and situated in the gearbox *d* shown in Figs. 3 and 4. The cutting traverse of the saddles is variable in infinitely-small steps between 4 in. per minute and 36 in. per minute, and the length of traverse is automatically controlled by adjustable stops. The quick-return traverse is 15 ft. per minute. The spindle motors are supplied with current through the drum-wound cables indicated at *e*, the cable being supported at intervals along the bed to ensure even tension as it is paid out or wound up. Should the double-headed machine be required for sawing the edges of spars, or otherwise used as a single-headed machine, the saddle *b* can be traversed to one end of the bed and clamped there.

SPAR-BOOM HORIZONTAL MILLING MACHINES.

MESSRS. A. C. WICKMAN, LIMITED, COVENTRY.

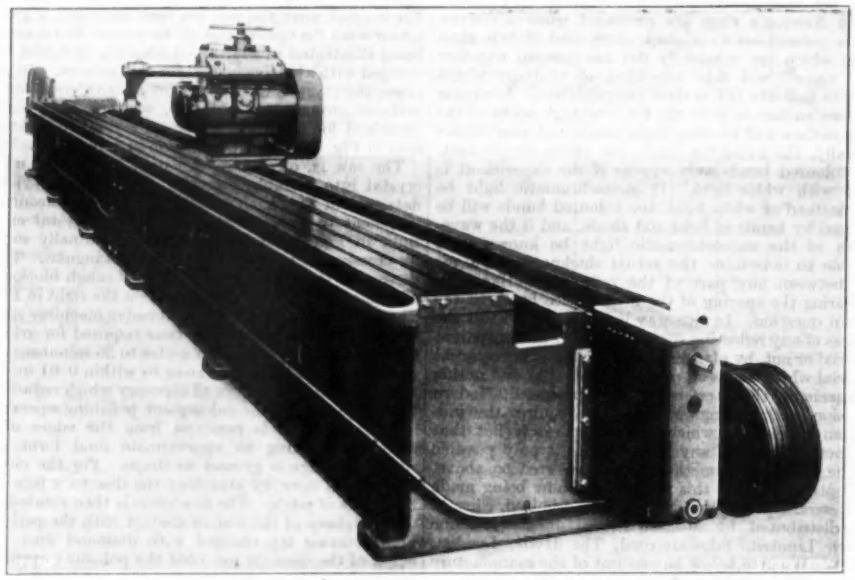


FIG. 1. SINGLE-HEADED MACHINE.

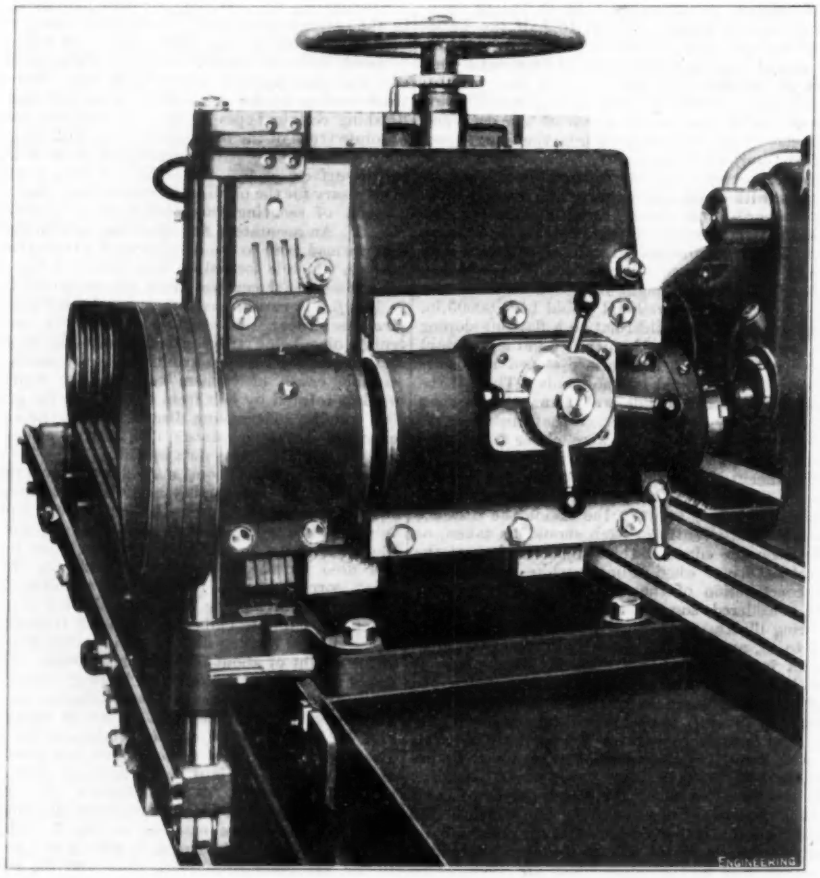


FIG. 2. SADDLES OF DOUBLE-HEADED MACHINE.

SPAR-BOOM HORIZONTAL MILLING MACHINES.

MESSRS. A. C. WICKMAN, LIMITED, COVENTRY.

Fig. 3.

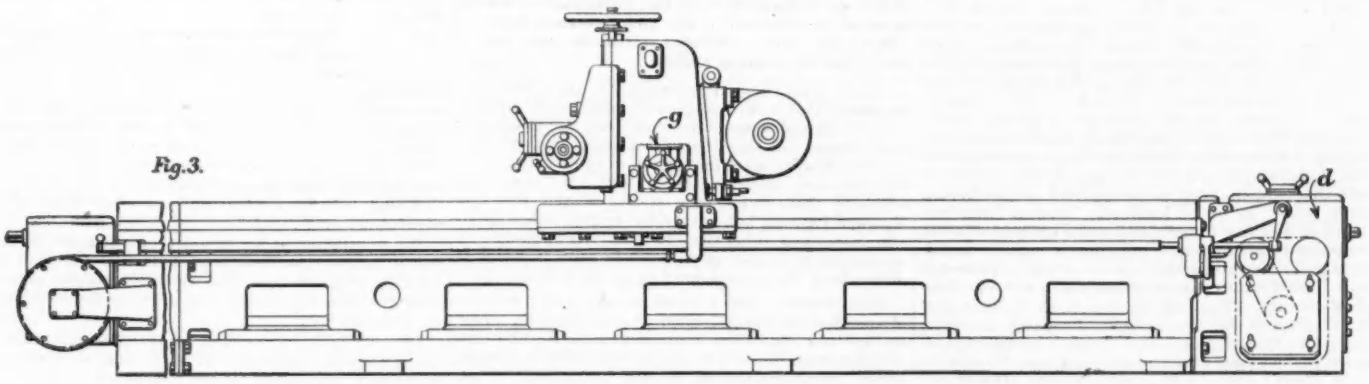
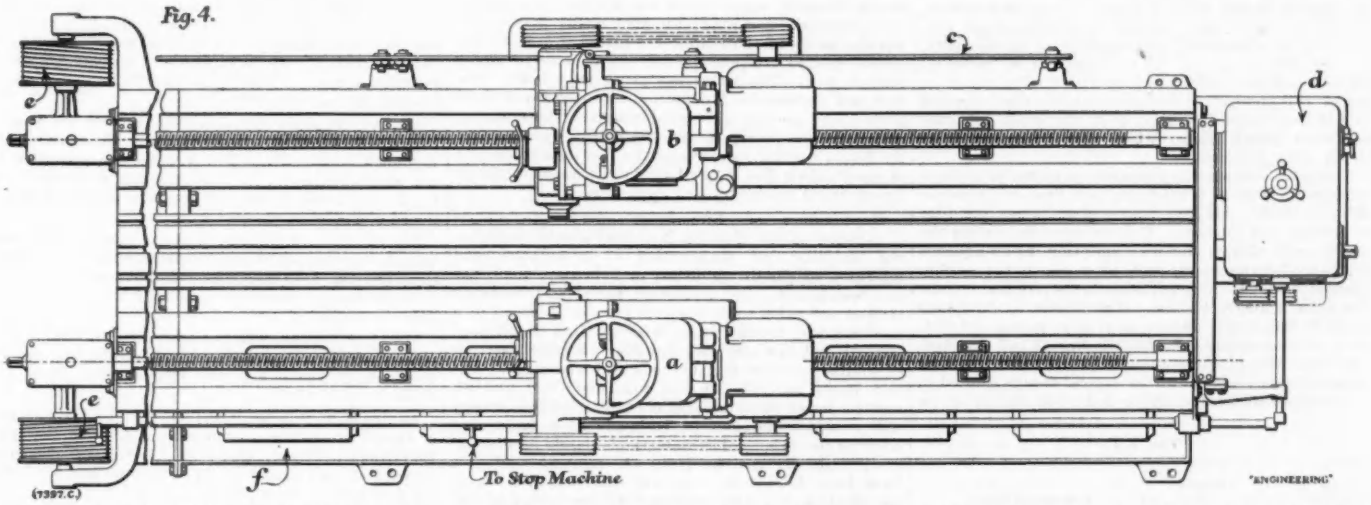


Fig. 4.



An outload arbor support is provided for saddle *a*, as shown in Fig. 1, but this can be readily detached when surfacing cutters are used. The machine top is provided with a trough at one side, indicated at *f* in Fig. 4 and visible to the left of Fig. 1. This receives the swarf and cutting fluid. The pump for the latter is carried on the saddle, at *g*, Fig. 3, and the tank extends for the full length of the bed, so that the pump can function in any position of the saddle.

TUNG OIL PRODUCTION IN AUSTRALIA.

SINCE its introduction into Europe and the United States of America at the end of last century, an ever-increasing number of uses have been found for tung oil, or Chinese wood oil. Especially valued in China for its waterproofing qualities, it has been used there for at least a thousand years for preserving and polishing wood, for waterproofing paper, in the manufacture of putty, paint and ink, medicinally, and in other ways. Western science is now applying the special properties of tung oil to the composition of rubber substitutes, linoleum and similar products. It is most widely used, however, in the manufacture of varnishes, paints and enamels, being an indispensable ingredient of certain special types of these, and it is an essential component of the lamp-black used in making Indian ink. Tung oil produced from the nut kernels by solvent processes is liable to change to a white solid, quite unsuited to paint manufacture; but the oils obtained by cold expression of Australian-grown tung fruit kernels are mobile, free from suspended matter, and of a pale straw colour eminently suited to this purpose. It is evident, therefore, that at a time when its uses are likely to be extended, those localities on the eastern seaboard of Australia, north of Sydney, which have been found to offer soil and climatic conditions appropriate for cultivation of the better yielding species of tung tree (*Aleurites Fordii* and *Aleurites Montana*) may be profitably developed into a source of Empire supply. The internal situation in China renders the chief producer an uncertain source; and the young industry of the United States, supplies as yet only about 2 per cent. of that country's requirements, which normally amount to some 16,000,000 gallons annually, or 75 per cent. of the world production.

American growers have been interested in tung oil for over 25 years, and some excellent publications have been issued on the composition of oil from cultivated trees, and the physical conditions best suited to tung cultivation, by Mr. Henry A. Gardner and his collaborators, under the auspices of the Paint Manufacturers' Association of the United States of America. Circular 225 of this Association, issued in December, 1925, furnished useful information on the machinery used for hulling and crushing tung seeds. The plant most favoured in America for the production of oil from tung fruit is that made by the V.D. Anderson Company, Cleveland, Ohio. This comprises an expeller with a disc-huller for removing shells from nuts, and equipment for separating hulls from the meal, together with an elevator, a disc-grinder and a filter press for filtering the oil. A 15-h.p. three-phase motor, running at 900 r.p.m. and operating at 220/440 volts and 60 cycles, is coupled directly to the expeller. The tempering apparatus, comprising a steam-jacketed conveyor-trough mounted over the expeller, requires a supply of steam at 80 lb. to 90 lb. per square inch to pre-warm the meal and promote "running" of the oil.

Quite recently, according to *Tung Oil*, published by the Sydney Technological Museum,* suitable plant for decorticating and expelling has become available in the United Kingdom. Twelve-inch hand-powered, as well as 15-in. and 24-in. mechanically-driven, decorticators are manufactured by Messrs. Richmond and Chandler, Manchester, and one of these, the 24-in. machine, can be supplemented by expelling plant designed to work in conjunction with it and made by Messrs. Rose, Downs and Thompson, Limited, Hull. The plant consists of a set of elevators to deliver decorticated material to a disintegrator; a second set of elevators then delivers disintegrated material to a continuous automatic oil-expeller, which, in turn, delivers oil into a settling tank having internal fittings for separating oil from sediment. This plant is complete with the necessary driving gear, which requires 26 brake horse-power and process steam at the rate of 100 lb. per hour. Messrs. Rose, Downs and Thompson also manufacture a clarification plant designed to de-slime and filter the crude oil obtained from the expeller. Use of the clarifier produces a bright, clear oil more quickly and efficiently than is the case when other methods, such as tanking, are employed.

During the period 1937 to 1939, inclusive, Tung Oil Mills, Limited, of Sydney, distributed 140,000 specially selected tung trees in New South Wales, where another 100,000 are being planted during the present year. Growers in New South Wales and Queensland, where about a quarter of a million trees have already been planted, number between 500 and 600. One of the deterrents to growers has been the imperative need for pioneering horticultural work to breed heavy-yielding trees, which are essential to the success of the industry; and, with trees which do not fruit for three or more years after planting, selection is a slow process. Moreover, Australia's droughts impose unwonted variations upon trees being grown experimentally; it has been found, however, that the trees showed great hardihood in one of the worst droughts on record in 1939, when, in fact, the second year's crushing undertaken at the Tung Oil Mills made 2,360 gallons, as compared with the 708 gallons made when crushing first took place in 1938. Australia's annual consumption is more than 160,000 gallons, and, in normal times, the United Kingdom uses 1,500,000 gallons of tung oil a year.

The horticultural problems involved have been discussed in detail in a paper contributed to the Royal Society of New South Wales.* Apart from the need to develop heavy-fruiting trees, previously mentioned, it appears that the chief preliminary requirement, to induce potential growers to undertake the cultivation of an unfamiliar crop, is the production of an efficient portable decorticator. Such a machine would enable growers to halve the weight of their produce as gathered, thus effecting a material reduction in the heavy cost of transport to the mills.

* *Bulletin No.* 12. *Tung Oil.* (Fourth edition). By A. R. Penfold and F. R. Morrison. Sydney: The Technological Museum. [Price 1*s.*]

* "Studies on the Tung Oil Tree." By S. Smith-White, B.Sc. (Agr.). *Proc. Royal Soc. N.S.W.*, vol. 74 page 42 (1940).

IMMERSION TINNING OF COPPER AND BRASS.

The tinning of small iron and steel articles, such as pins, eyelets and paper clips, by simple immersion in a suitable solution has long been practised. The process, which is one of electro-chemical displacement, has also been used, to a limited extent, for coating copper and brass articles, but it is generally necessary for the articles to be in contact with another metal, usually zinc, by means of which an electrolytic cell is formed. The composition of the solutions employed varies somewhat, but a bath which is widely used for immersion tinning contains cream of tartar (acid potassium tartrate) and stannous chloride. A feature of the process is that the solution must be maintained at the boiling point while in use. Particular interest attaches, therefore, to a new tinning bath which operates at room temperature and without requiring a contact metal. Information regarding this process, which is protected by a United States patent, was given in a recent issue of *Metals and Alloys*, by Messrs. J. D. Sullivan and A. E. Pavlish, of the Battelle Memorial Institute, Columbus, Ohio, U.S.A. This article is commented on in the current issue of the quarterly review, *Tin and Its Uses*, issued by the Tin Research Institute. It is stated that the treatment produces uniform, adherent tin coatings on copper, red and yellow brasses, commercial copper-tin alloys, and bronzes containing small percentages of aluminium and other alloying elements. Other materials, such as iron and steel, can be tinned by the new process if they are first coated with copper or brass. It is pointed out that the method is easily applied to articles of intricate shape, or to the insides of pipes and even coiled tubing, which would be difficult to tin by other processes.

The bath contains 50 grammes per litre of sodium cyanide (NaCN); 5 grammes per litre of stannous chloride ($SnCl_2 . 2H_2O$); and 5·6 grammes per litre of caustic soda (NaOH). It is prepared by adding the caustic soda slowly, and with agitation, to an aqueous solution of stannous chloride, after which the sodium cyanide is added. Upon dilution to the required volume the bath is ready for use. The article to be tinned must be thoroughly cleaned to remove grease and dirt, after which pickling is preferable, though not essential. The thickness of the coating depends upon the time of immersion, as is shown by typical results quoted in Table I. If the coated article be heated slightly above

Table I.

Period of Immersion.	Thickness of Coating.	Weight of Coating.	
	In.	Gm. per sq. dm.	Oz. per sq. ft.
5 min.	0·000004	0·006	0·0020
15 ,,	0·000006	0·012	0·0039
30 ,,	0·000009	0·017	0·0056
1 hour	0·000014	0·026	0·0085
2 ,,	0·000021	0·040	0·0131
24 ,,	0·00014	0·262	0·0858

the melting point of tin, the coating forms an alloy with the copper base. The surface may then be given an additional immersion treatment resulting in the production of three distinct layers, namely, the underlying copper, a diffused layer of copper-tin alloy and the final tin coating.

The new process, which is recommended for its simplicity—the only equipment required being a wood or steel tank—can be employed for tinning a wide variety of copper or brass articles, such as pipes, tubes, and plumbing fittings, on which a relatively thin coating of tin is required to improve the appearance or the corrosion resistance. A brass or copper vessel can be tinned on the inside by filling it with the solution and allowing it to stand until the required thickness of coating has been deposited. The insides of pipes and tubes can be coated either by circulating the solution through them or by filling them with the solution for the required time and then draining and washing. If the sodium cyanide content of the bath is maintained constant at 50 grammes per litre, it has been found that the concentration of tin can be varied within wide limits, but that it must be in the stannous condition. Provided, however, that the bath contains sufficient stannous tin, fairly high concentrations of stannic tin can be tolerated with no ill effect. Stannous tin tends to oxidise in the bath and sodium cyanide decomposes slowly—as is the case with cyanide electroplating solutions. Hence periodic titrations should be made to ensure that the concentrations of stannous tin and of sodium cyanide are adequate. Otherwise, it is stated, no particular attention is needed to maintain the bath in working order, the process thus being very economical in operation. It is added that the copper dissolved from the copper or brass articles, as the result of electrolytic action, does not cause trouble in normal operations.

BRITISH STANDARD SPECIFICATIONS.

The following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 3*d.* including postage.

Screw-Thread Gauge Tolerances.—On page 368, *ante*, we stated that a war-emergency specification relating to screw-thread gauge tolerances (No. 919-1940) had been issued, and that the tolerances recommended in this specification were formulated in co-operation with the National Physical Laboratory. We are now informed that, during the period of the war, the National Physical Laboratory has agreed, unless specially instructed otherwise, to test screw gauges in accordance with this specification in cases in which it differs from the current practice of the Laboratory.

Motor Starters and Controllers.—A second revision of specification No. 587-1940, which deals with motor starters and controllers and resistors employed therewith (excluding liquid starters and controllers and single-phase alternating-current types), has recently been published. A few additional clauses have been introduced, the more important of which relate to a mechanical endurance test applied in such a way that all the working parts of the starter are included, and to the clearances and creeping distances applicable to motor control gear. The latter are given in tabular form in a new appendix. A definition of a damp and dust-protecting type has also been inserted. Appendix C, in the previous (1938) edition, which dealt with terminal markings, has been superseded by Sections 10 and 11 of specification No. 822, relating to terminal markings for electrical machinery and apparatus.

Examination of Bituminous Road Mixtures.—A revision of specification No. 598, which relates to the sampling and examination of bituminous road mixtures, originally published in February, 1936, has now been issued. Certain sections have been completely revised and other main features are the inclusion of a modified test for the rapid determination of bitumen content and two alternative methods for the recovery of soluble bitumen for subsequent examination. The two latter methods are recommended as tentative, and it is hoped that the experience obtained by industry will enable a decision to be made at a later date whether one or both of these methods should be adopted as British Standards. Tests on mineral aggregate have been deleted as these are now provided for in specification No. 812, dealing with the sampling and testing of mineral aggregate, sands and fillers. [Price 3*s.* 6*d.* net, or 3*s.* 9*d.* including postage.]

BOOKS RECEIVED.

Electrical Contacts. By G. Windred. London: Macmillan and Company, Limited. [Price 16*s.* net.]

Science Versus Materialism. By Professor R. O. Kapp. London: Methuen and Company, Limited. [Price 10*s.* 6*d.* net.]

Graphic Treatment of Vibration and Aircraft Engine Dampers. By Dr. C. H. Powell. Brooklyn, New York City, U.S.A.: Bookcraft. [Price 7.50 dols.]

Elements of Acoustical Engineering. By Dr. H. F. Olson. London: Chapman and Hall, Limited. [Price 30*s.* net.]

The High-Speed Compression-Ignition Engine. By C. B. Dicksee. London: Blackie and Son, Limited. [Price 16*s.* net.]

United States Bureau of Mines. Natural Gasoline and Liquefied Petroleum Gases. By G. R. Hopkins. Washington: Superintendent of Documents. [Price 5 cents.]

United States Bureau of Mines. Technical Paper No. 611. *Friability, Grindability, Chemical Analyses and High- and Low-Temperature Carbonization Assays of Alabama Coals.* By E. S. Hertzog, J. R. Cudworth, W. A. Selvig and W. H. Ode. Washington: Superintendent of Documents. [Price 15 cents.]

United States National Bureau of Standards. Building Materials and Structures. Report BMS 52. *Effect of Ceiling Insulation Upon Summer Comfort.* By T. D. Phillips. Washington: Superintendent of Documents. [Price 10 cents.]

Department of Scientific and Industrial Research. Fuel Research. Physical and Chemical Survey of the National Coal Resources. No. 44. *Methods of Analysis of Coal and Coke.* London: H.M. Stationery Office. [Price 2*s.* net.]

Practical Solution of Torsional Vibration Problems. With Examples from Marine, Electrical, Aeronautical, and Automobile Engineering Practice. By Dr. W. Ker Wilson. Second edition. Volume I. London: Chapman and Hall, Limited. [Price 42*s.* net.]

PERSONAL.

Messrs. Wellworthy Piston Rings, Limited, Lymington, Hants, inform us that their service depot at 143, Suffolk-street, Birmingham, W.1, has been transferred to Somerset House, Temple-street, Birmingham, 1.

Mr. R. A. Kirkby has been appointed chairman of the Glenboig Union Fireclay Company, Limited, Glenboig, and of Messrs. Henry Foster and Company, Limited, Backworth, in succession to Sir Ronald W. Matthews, J.P., who has resigned owing to pressure of work. Sir Ronald, however, retains his seat on the boards of these two companies which are subsidiaries of General Refractories, Limited. Mr. Alexander McKendrick, who was formerly joint managing director of the Glenboig Company, with Mr. Kirkby, now becomes sole managing director.

Dr. F. Meyer, B.A., M.Sc., works manager of the South African Iron and Steel Industrial Corporation, Limited, Pretoria, has been elected President of the Transvaal Iron and Steel and Engineering Federation for the ensuing year.

Mr. A. Dunbar, a director of Messrs. Vickers-Armstrongs Limited, will, in future be known as Director in charge of the Aircraft Section. Major H. R. Kilner, M.C., also a director of Messrs. Vickers-Armstrongs, has been appointed general manager of the Aircraft Section. Another director of the firm, Mr. A. J. Palmer, has been made general manager of the Crayford and Dartford Works. Mr. A. E. Reddell has been appointed general manager of The Whitehead Torpedo Company, Limited, as from October 1.

Mr. W. H. Grieve, managing director of Messrs. Lightalloys, Limited, Alpax Works, St. Leonard's-road, Willesden Junction, London, N.W.10, has succeeded to the chairmanship of the firm in place of Captain O. Lyttelton, who resigned on becoming President of the Board of Trade.

Sir Clive L. Baillieu, K.B.E., C.M.G., has been elected chairman of Messrs. Imperial Smelting Corporation, Limited, 95, Gresham-street, London, E.C.2. Mr. L. B. Robinson has been appointed a director of the firm.

Mr. A. J. Baker, who has been assistant engineer-in-chief of the New Zealand Public Works Department for the past 11 years, has now retired. He joined the Department in 1898.

Mr. John Anderson, A.M.I.Mech.E., general manager of Messrs. Ruths Arca Accumulators, Limited, 36, West End-avenue, Pinner, Middlesex, has been elected a director of the Company. Mr. Anderson has been with the firm since its inception.

TENDERS.

We have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Sawmill Machinery, comprising one head-block type circular sawmill; one pendulum-type cross-cut saw; one edging machine, and saw-sharpening and setting machinery. Town Clerk, City Hall, Cape Town; December 10. (T. 22,623/40.)

Rotary Converter or Mercury-Arc Rectifier, namely, a 200-kW manually-controlled rotary converter, or, alternatively, a 200-kW mercury-arc rectifier, or two 100-kW mercury-arc rectifiers, for Cottesloe Gas Works. The supply is three-phase current at 6,600 volts and 50 cycles, and a direct-current output of 200 kW at 220 volts is required. City Council, Johannesburg; January 4, 1941. (T. 22,424/40.)

Institute of Petroleum.—The Council of the Institute of Petroleum has awarded an Institute Scholarship, valued at 40*l.* per annum and tenable for the year 1940-41 at the Imperial College of Science and Technology, to Mr. Geoffrey Jardine Clarke, a student at the Royal School of Mines.

British Technical Journals in the United States.—We are informed that, in spite of the war, the Engineering Societies Library, 29, West 39th-street, New York, U.S.A., is experiencing no difficulty in obtaining technical periodicals from Great Britain. On the other hand, only a few engineering magazines now reach the Library from Continental Europe. It is stated that the 350 periodicals normally received from Great Britain and other parts of the British Empire are coming through with exceptional regularity. Only in one or two instances has a batch failed to arrive; these lost copies, however, were quickly replaced as a result of correspondence with the publishers concerned.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Another attempt to secure for South Wales an increased share of the home trade is to be made by the South Wales Miners' Federation. It was pointed out during the week that the opposition to the proposal which had been raised by owners and men in the Midland and Yorkshire coalfields no longer applied, since these coalfields could not meet the demands which were made upon them and would welcome assistance. Conditions on the market were without much change. There was a sustained request from inland sources for high volatile bituminous coals for industrial purposes. Dry steams attracted little attention; collieries producing them were only irregularly employed and the tone was dull. Best large sorts moved off satisfactorily and prices were maintained while a keen interest was displayed in the popular sized kinds, which were well stemmed ahead and firm. Bituminous smalls were scarce, but dry smalls were in plentiful supply to meet a slow request and were dull. Cokes were busy, but patent fuel was slow.

The Iron and Steel Trade.—Activities were well maintained in the iron and steel and allied trades of South Wales and Monmouthshire during the past week. The demand was maintained and the works generally were kept busily employed on orders already in hand.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The aggregate tonnage output of iron and steel is maintained at an extremely high level and, aided by considerable imports of products from the United States, the supply is being kept adequate for the essential current needs. The bulk of the available tonnage is still absorbed by priority delivery claims, but while the conditions necessitate strict adherence to the control of distribution regulations, they permit the release of a little additional tonnage for ordinary industrial purposes.

Cleveland Iron Trade.—Merchants are handling slightly more Cleveland pig iron than has recently been the case, but their holdings are still light and as makers, apparently, do not intend to increase the moderate intermittent output, foundry-iron consumers are dependent on supplies from elsewhere. Foundries are turning out larger tonnages than they have been doing for some time and, notwithstanding the extensive employment of scrap iron, are using increasing quantities of pig, of which there is no shortage. Deliveries of Midland brands are quite satisfactory and adequate parcels of Scottish iron are obtainable for special purposes. The recognised market value of No. 3 Cleveland pig remains at 128*s.*, delivered within the Tees-side zone.

Hematite.—Purchases of American hematite and the well-maintained heavy production of local iron is expected to meet the large and expanding demand. Meanwhile, all available tonnage is passing promptly into use and pressure for larger deliveries continues. At present, second hands are unable to increase their holdings sufficiently to meet the needs of their regular customers. Hematite consumers dependent on the market for supplies, though not obtaining full contract deliveries, are receiving substantial parcels. The large and expanding needs of consuming works owned by hematite producers continue to absorb most of the available iron. No. 1 description of East Coast hematite is quoted at 138*s.* 6*d.*, delivered to North of England areas, 144*s.* to Sheffield, and 150*s.* to Birmingham.

Basic Iron.—The whole of the basic iron output is still retained for use at makers' adjoining steelworks and the quotation of 121*s.* is nominal.

Foreign Ore.—Cargoes of foreign ore continue to arrive regularly and consumers' stocks are quite satisfactory.

Blast-Furnace Coke.—Little effort is made to effect transactions in Durham blast-furnace coke. Local users are well covered, and sellers' contract obligations are as extensive as is thought to be advisable.

Manufactured Iron and Steel.—Ample deliveries of semi-finished iron and steel are enabling the re-rollers to operate their mills so as to obtain the maximum output. Manufactured-iron firms have a great deal of work to execute and producers of finished steel are fully sold to well beyond the end of the year. The distribution of structural steel is maintained on an extensive scale, and large deliveries of plates, angles, etc., are sufficient for the requirements of the shipbuilders. Soft-steel billets are quoted at 12*l.* 5*s.* per ton; hard billets at 13*l.* 12*s.* 6*d.* per ton; joists and sections at 15*l.* 8*s.* per ton; plates at 16*l.* 3*s.* per ton; and heavy rails at 14*l.* 10*s.* 6*d.* per ton.

Scrap.—Iron and steel scrap is plentiful. Consumers have good stocks, but, with the exception of the lighter grades of material, are still accepting deliveries.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The general position of the staple trades of this area is that there is plenty of work in hand and much more in sight. Export trade continues to develop on satisfactory lines. Despite the pressure of Government orders, industrialists are not losing sight of the fact that export trade is essential, and steps are being taken to improve sales in overseas markets. Large batteries of furnaces are accounting for heavy outputs of raw and semi-finished steels. There is an active demand for basic steel; but forward buying of any class of steel is out of the question. Rolling mills, forges, and press shops are all operating at full capacity. There is a brisk demand for structural steel, including angles, joists, and bars; and wire ropes and all types of springs, especially those used for railway work, are in strong request. Orders are circulating freely for heavy machinery and engineering equipment. Among the lines in demand are cement-mixing plant, rotary dryers, pulverising plant, lime hydrators, and dredging plant. Manufacturers of cement-making plant are using larger quantities of high-efficiency steels; tubes made of heat-resisting steel are in strong demand. Seamless drums are required for various purposes, and there is a steady call for welded-steel cooling chambers, mains, etc., in connection with the low-temperature carbonisation of coal. Rolling-mill plant for the production of cold-rolled strip is also on order. The medium branches continue to be actively employed, and agricultural machinery, parts, and implements are in satisfactory request considering the time of the year. The tool-making trades are busy.

South Yorkshire Coal Trade.—Heavy buying is taking place in most types of fuel. Stocks are being built up by all the large works and power stations, as well as by householders. Steam coal is active and locomotive fuel is in fairly strong demand. The house-coal market is particularly active, and there is a strong call for all classes of coke.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The increase in prices already notified has made practically no change in the steel trade of Scotland owing to the fact that the material is necessary for immediate requirements and supply is more important than cost. Every endeavour is being made to maintain production at the high standard of recent months. Government contracts are still absorbing the bulk of the current output and steel for other purposes is not easy to obtain in large quantities. A certain amount of export business is being transacted but every application for a licence is carefully considered before a permit is granted. Specifications from shipbuilders and other buyers of heavy material have been coming to hand in increasing numbers and the demands being made for black and galvanised sheets represent a large tonnage which is sufficient to ensure the steady running of plant for many months. Sectional material is also in strong demand, but the stocks of raw material have been accumulating in a satisfactory manner, and the production outlook for the winter months is entirely satisfactory. The following are the current prices:—Boiler plates, 17*l.* 0*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, rolled in sheet mills, ¼ in. and thicker, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton. It will be noted that the increases in these prices vary from 35*s.* per ton on sections to 70*s.* per ton on galvanised sheets.

Malleable-Iron Trade.—In the malleable-iron trade of the West of Scotland a satisfactory amount of business is passing and makers are fully employed. The demand for re-rolled steel bars is still on a large scale and, as there is no shortage of semies, production is at a maximum. The new prices are as follows:—Crown bars, 15*l.* 12*s.* 6*d.* per ton, an advance of 10*s.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton, and No. 4 bars 13*l.* 17*s.* 6*d.* per ton, each marking an advance of 5*s.* per ton; re-rolled steel bars, 17*l.* 15*s.* per ton.

Scottish Pig-Iron Trade.—Active conditions are general in the Scottish pig-iron industry and as ample supplies of iron ore have been accumulated, all the furnaces in blast are working at full capacity. The requirements of the steel trade continue to be heavy and the output is rapidly taken up, but orders for foundry grades are still rather slow. The recent advance in prices makes the current quotations as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steelworks. Foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both quotations being for iron on trucks at makers' yards.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF MECHANICAL ENGINEERS.—To-night, 6 p.m., Storey's-gate, St. James's Park, Westminster, S.W.1. General Meeting. Twenty-Seventh Thomas Hawksley Lecture: "Combustion," by Professor A. C. G. Egerton.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—To-night, 6 p.m., The Mining Institute, Newcastle-upon-Tyne. "Vibration Patterns of Propeller Blades," by Dr. G. S. Baker. *Student Section:* Wednesday, November 20, 6.45 p.m., Bolbec Hall, Newcastle-upon-Tyne. Exhibition of Technical Films.

JUNIOR INSTITUTION OF ENGINEERS.—Saturday, November 16, 1.30 p.m., 39, Victoria-street, Westminster, S.W.1. Annual General Meeting.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, November 16, 2 p.m., Neville Hall, Newcastle-upon-Tyne. General Meeting. "Observation on Roof Spotting," by Captain L. T. Griffin.

ROYAL SOCIETY OF ARTS.—Monday, November 18, 1.45 p.m., John Adam-street, Adelphi, W.C.2. Cantor Lectures—I. "Recent Developments in Internal-Combustion Engines," by Professor S. J. Davies.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 19, 1.30 p.m., Great George-street, Westminster, S.W.1. Ordinary Meeting. Dugald Clerk Lecture: "Methods of Excavation Work at Home and Abroad," by Mr. William Barnes.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Tuesday, November 19, 6.30 p.m., The Lighting Service Bureau, 2, Savoy-hill, Strand, W.C.2. "Earthing," by Mr. H. W. Grimmett.

SOCIETY OF GLASS TECHNOLOGY.—Wednesday, November 20, 2 p.m., The University of Sheffield, "Elmfield," Northumberland-road, Sheffield, 10. Ordinary General Meeting. (i) "The Softening Point of Glass," by Dr. J. T. Littleton, to be presented by Professor W. E. S. Turner. (ii) "Standard Discs in the Strain Testing of Glassware," by Dr. E. J. Gooding. (iii) "Geometrical Considerations in Glass," by Professor B. E. Warren. (iv) "The Relation of Fineness to Physical Requirements," by Professor A. H. M. Andreasen.

INSTITUTION OF MINING AND METALLURGY.—Thursday, November 21, 2.30 p.m., The Geological Society's Rooms, Burlington House, Piccadilly, W.1. Ordinary General Meeting. (i) "The Lead-Zinc Mineral Resources of Great Britain," by Mr. W. R. Jones. (ii) "A Graphical Method of Adjusting Underground Traverses in Mine Surveys," by Mr. W. H. Wilson.

MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, November 23, 2.30 p.m., The Engineer's Club, Albert-square, Manchester. "Line Production of Machine Tools" by Mr. O. Rendell.

THE MANUFACTURE OF DOALL BAND SAWS.—A new factory, occupying some 15,000 sq. ft. of floor space, has recently been opened by The Doall Company, at 1201-1225, Thacker-street, Des Plaines, Illinois, U.S.A., for the production of narrow precision band saws for metal cutting. The saws are for use primarily in the Doall contour machine, made by Continental Machines, Incorporated, Minneapolis, and illustrated descriptions of which appeared in ENGINEERING, vol. 146, page 83 (1938), and vol. 148, page 729 (1939).

THE JULIAN C. SMITH MEMORIAL MEDAL.—To perpetuate the memory of the late Mr. Julian Cleveland Smith, a distinguished engineer and 39th President of the Engineering Institute of Canada, a Julian C. Smith Memorial Medal, to be awarded "for achievement in the development of Canada," has been established. The Council of the Institute has given a committee of past-presidents the task of recommending the terms and conditions under which the Medal will be awarded. It has been suggested that several awards be made for the inaugural year, although it is intended that not more than one award be made annually thereafter.

BUILDING OF A THIRD BLAST-FURNACE AT PRETORIA.—The current issue of the journal *Iscor News* contains the announcement that a third blast-furnace is to be erected at the Iscor Works of the South African Iron and Steel Industrial Corporation, Limited, Pretoria. Excavation for the new furnace, which—like furnaces No. 1 and No. 2—will be 86 ft. 6 in. in height and have a hearth diameter of 16 ft., has already been put in hand. The furnace has been designed to produce 600 tons of iron per day. It will be recalled that descriptions of the two existing furnaces at the Iscor plant appeared recently in our columns, on pages 299 and 315, *ante*.

INTERFERENCE EFFECTS WITH OPTICAL FLATS.

MESSRS. OPTICAL MEASURING TOOLS, LIMITED, SLOUGH.

(*For Description, see page* 385.)

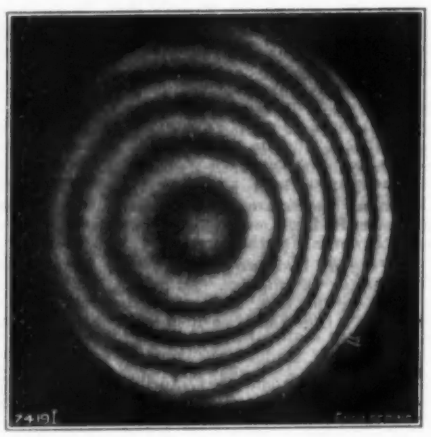


FIG. 9. SPHERICAL SURFACE.

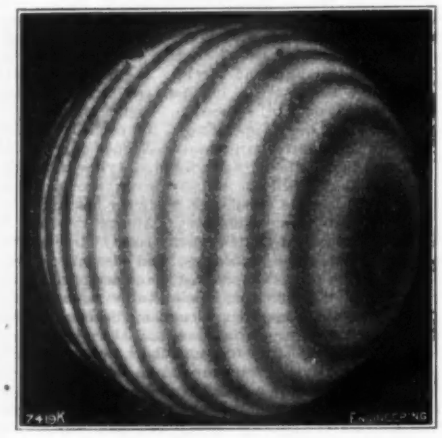


FIG. 10. PARTIALLY CURVED SURFACE.

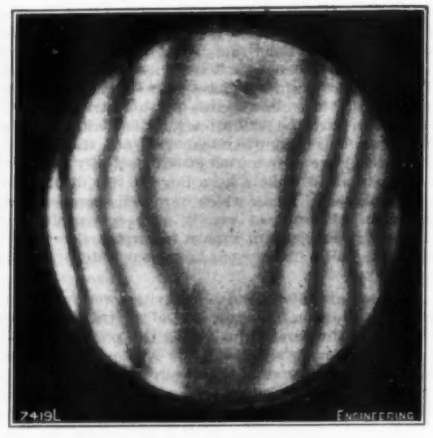


FIG. 11. CENTRAL RIDGE OR DEPRESSION.

FIG. 12. IRREGULAR SURFACE.

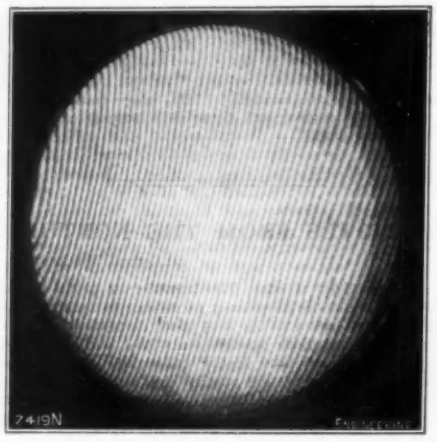


FIG. 13. FLAT SURFACE EXAMINED WITH TILTED OPTICAL FLAT.

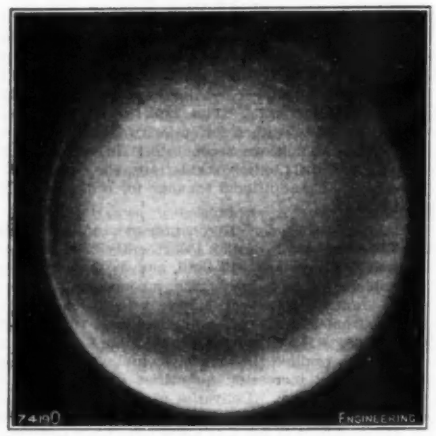


FIG. 14. FLAT SURFACE WITH CLOSE CONTACT.

SURFACE TREATMENT OF STEEL PRIOR TO PAINTING.

THE growing demand for steel sheet for building purposes has prompted the United States Bureau of Standards to conduct a comprehensive investigation on methods intended to lengthen the service life of the material by improving the durability of paint films applied to the surface. The investigation, which was commenced two years ago as part of a general research programme on building materials for the construction of inexpensive houses, consists in conducting a number of accelerated laboratory corrosion tests on painted panels of plain and galvanised steel sheet, supplemented by outdoor exposure tests of similarly treated materials at Washington. A report* by Mr. R. E. Pollard and Mr. W. C. Porter, numbered BMS 44, has recently been issued on the subject, in which it is stated that sufficient time has not yet elapsed for the outdoor tests to produce significant results, but that a considerable amount of useful information has been accumulated from the results of the salt-spray and accelerated-weathering tests. As already indicated, the investigation is mainly concerned with the treatment of the surface prior to painting, in order to provide an improved base for the paint. The steel-sheet panels used in all the tests consisted of plain hot-rolled annealed material and of hot-dip zinc-coated, or galvanised, sheet. Some measured 3 in. by 6 in. and others 5 in. by 7 in.

Specimens of plain steel were subjected to ten different pre-treatment processes prior to painting. These included pickling in hot aqueous solutions of hydrochloric, phosphoric or sulphuric acids; hot-dipping in aqueous zinc-phosphate, chromic-acid or oxalate solutions containing also, in some cases, free phosphoric acid, and, in others, an activating agent; and various cold washes containing aqueous solutions of phosphate and chromates and phosphoric acid. The galvanised-steel specimens were also treated by hot-dipping in zinc-phosphate or oxalate-phosphate solutions, or by cold-washing in zinc-phosphate solutions. One treatment consisted in immersing the specimen in a cold aqueous sodium-dichromate solution containing sulphuric acid. As alternatives, however, various etching treatments were applied. These consisted of aqueous solutions of copper or zinc sulphate, or acetic acid, or of mixtures of salts with acids. Two of the etching media contained large proportions of alcohol. After the pre-treatment, the plain and galvanised specimens were brushed, as a rule, with two coats of priming paint, a week being allowed for drying between the application of the coats. One half of the surface of each panel was then given a final coat of "outside-finishing" paint, and most of the painted panels were scratched diagonally before being tested. The composition of the paints is not given in the report.

The salt-spray test employed consisted in exposing the painted panels continuously, in some cases for as long as 365 days, to the fine mist or spray produced by atomising a 20-per cent. aqueous solution of sodium chloride at 35 deg. C. In the accelerated-weathering test, painted panels were exposed, alternately wet and dry, to the heat and light of a carbon-arc lamp. A condensation-corrosion test also carried out, on painted galvanised-steel panels only, consisted essentially in exposing prepared panels to the action of moisture condensed from a controlled atmosphere. The panels rested in a nearly horizontal position on the surface of a water tank forming the bottom of an insulated box through which air of controlled temperature and humidity was circulated.

The salt-spray and accelerated-weathering tests conducted on the plain steel panels indicated that the hot-dip phosphate treatments markedly improved the protective value of the paints in both tests. The phosphate-chromate cold-wash treatments were found to be only slightly inferior to the hot-dip phosphate treatments in the improvement of paint protection. The hot-dip chromic-acid treatment improved the paint protection as compared with a plain pickled surface, but the improvement was not so marked as that obtained with the treatment already mentioned. All the other treatments tested were found to have only a slight or negligible effect in improving the protective value of the paints. Under the severely-corrosive conditions of the salt-spray test, the protective value of paints applied on rusted surfaces was definitely inferior to that of paints applied on plain pickled surfaces. Some of the pre-treatments were apparently able to remove light rust. They were much more effective, however, when employed on a rust-free surface.

The tests conducted on the galvanised-steel panels showed that the hot-dip and also the cold-wash phosphate treatment improved both the adhesion and the corrosion-protection value of paints under widely varying conditions. Apparently, however, the hot-dip treatments were slightly superior to the cold washes. The acid-dichromate treatment, it appeared, had considerable protective value in itself and had an inhibitive action under the paints, but did not improve their adhesion. The oxalate-phosphate treatment prolonged the protective value of inhibitive paints under the severely corrosive conditions of the salt-spray test, but it had little effect on other types of paint and did not improve adhesion to any appreciable extent. All other pre-treatments investigated were found to have a slight or negligible effect in improving the protective value of paints. Tests of other types of zinc-coated materials are being carried out but have not progressed sufficiently to warrant the drawing of conclusions. These materials include zinc-plated, zinc-sprayed and annealed hot-dip galvanised surfaces.

* Superintendent of Documents, U.S. Government Printing Office, Washington. [Price 10 cents.]

THE MANUFACTURE OF QUARTZ OPTICAL FLATS.

MESSRS. OPTICAL MEASURING TOOLS, LIMITED, SLOUGH.

(*For Description, see Page* 385.)

FIG. 1. QUARTZ CRYSTALS AND FINISHED OPTICAL FLATS.

FIG. 2. SAWING ENDS OFF QUARTZ CRYSTALS.

FIG. 3. POLISHING CUT FACE OF CRYSTAL.

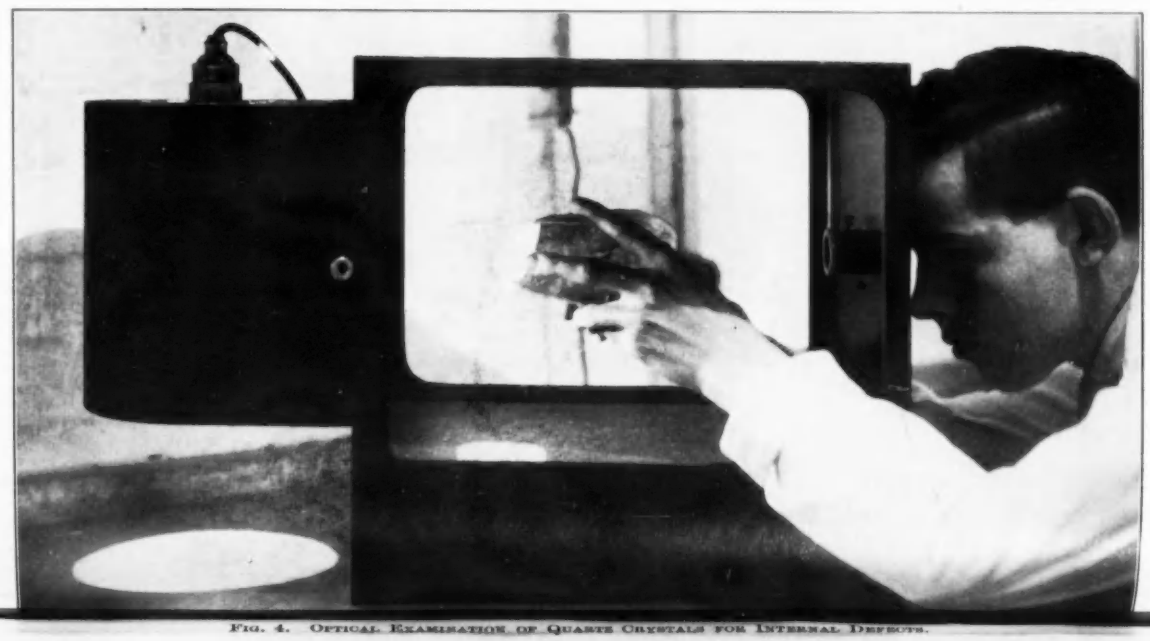


FIG. 4. OPTICAL EXAMINATION OF QUARTZ CRYSTALS FOR INTERNAL DEFECTS.

Fig. 3. Polishing Out Face of Crystal.

Fig. 4. Optical Examination of Quartz Crystals for Internal Defects.

Fig. 5. Truing a Pitch Polishing Disc.

Fig. 6. Truing Metal Discs for Use on Pitch Polishing Discs.

Fig. 7. Polishing Optical Flats on Pitch Tables.

Fig. 8. Polishing Special Optical Flats by Hand.

UNIV. OF MICH.

ENGINEERING.

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Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, NOVEMBER 15, 1940.

VOL. 150. No. 3905.

PLANNING FOR THE FUTURE.

IN no direction, perhaps, is the strength of purpose of the British people better exemplified than in the constant discussions that are taking place on how best to build a better world when peace shall have been restored again to Europe. There can be no question that the whole nation is not only determined that victory shall be won, but that the fruits of victory shall be worth the garnering. It is recognised that further great sacrifices will have to be faced and that, if these sacrifices are to be justified, the difficult and complicated task of ensuring a lasting peace must be undertaken now, and not left until the imminence of peace leaves no time for constructive planning. This conclusion is implicit in the presidential addresses to the Institution of Engineers and Shipbuilders in Scotland and the North-East Coast Institution of Engineers and Shipbuilders, upon which we commented a fortnight ago. The considerations to which it naturally gives rise were further developed on the broadest lines in the inaugural address to the Institution of Electrical Engineers, delivered on October 24 by Mr. J. R. Beard.

The address, an abridgment of which was begun on page 375, *ante*, was divided into two main sections. In the first, Mr. Beard dealt in general terms with the fundamental considerations which should govern the planning of the post-war world. In the second, he discussed in more detail the methods by which the electricity-supply industry, with which he has been closely connected for many years, should be reorganised in the light of the same broad principles. To attempt to discuss the address as a whole is quite impracticable within the limits of a single article, for it was replete with comments and suggestions, any of which might have served alone as text for an evening's debate, had they been presented at an ordinary meeting; but some endeavour must be made to examine his survey of the general trends of the time, for the address is certain to be widely studied and, probably, quoted—it is to be hoped, with due regard to the context and to the qualifications premised, without which the meaning and intent of some passages might be given a bias that, in fact, they do not possess. Consideration of the more technical problems referred to in the second part of the address must, perforce, be deferred to another occasion.

At the outset, Mr. Beard made an assumption—or, rather, three assumptions linked as one—which are all-important in relation to the expressions of opinion which followed. "May I assume," he said, "that we all recognise that the war is bringing about tremendous changes, not only in our environment, but in our whole outlook, and that we are all prepared to agree that the old order was no longer producing a healthy and happy community, and that apathy, selfishness and discontent, too much freedom in some directions and too little in others, were gradually undermining the character and vigour of the democratic nations." These are fairly sweeping assumptions, and it does not follow that any given individual will be prepared to accept all three of them with equal readiness; yet the whole argument that followed was dependent upon their acceptance. Mr. Beard went on to affirm the British loathing of "this so-called 'new order'" of Nazism and Fascism—an assertion which is amply supported by the general public attitude in the present struggle—but then proceeded to make yet another assumption in terms more assured than seem to be justified: "But as we are agreed that there can be no return to the 'old order,' it becomes of paramount importance to consider what kind of order we intend to set in its place."

This declaration, at first sight so definite and unequivocal, is actually capable of more than one interpretation. If it merely indicates or assumes a general agreement that there can be no return to the "old order" because the march of events renders such a return impracticable, that is one thing; but if it means that there can be no return to the "old order" because "we are agreed" not to permit such a return, that is quite another. Unfortunately, there are influences at work now, as there have been for a number of years in this country, which are prepared to overthrow almost any existing order as a step on the way to the establishment of some idealistic state in which their own pet theories and "-isms" shall ride triumphant over all present principles of democratic government and standards of public order; and it does not require much imagination to see which interpretation they are likely to prefer. That this is not Mr. Beard's intended meaning is sufficiently clear from his subsequent warning against permitting too extreme a reaction to the occasional abuse of money power which has been acquired through the earning of profit. "We should take care," he observed, "lest, reacting to such abuse, we swing over too readily to the alternative of obtaining power by position. This can be equally harmful if unchecked and would seem to be a great danger at the present time, even under cover of such high-sounding terms as public ownership and nationalisation." This was well said, and it is well that it should be said; for there is no doubt that the theoretical advantages of such large-scale schemes for centralisation are still apt to outweigh, in the minds of many who find it easier to accept ready-made ideas than to formulate their own, the proved disadvantages of the "vast bureaucratic organisations, bound in red tape, slow and inefficient in action, and coldly impersonal in spirit," to which Mr. Beard pointed as one of the chief dangers arising from attempts at over-simplification in communal affairs.

With Mr. Beard's main contention that planning for the future is essential if orderly progress is to be achieved, there can be little disagreement; and his recognition that planning, to be translated effectively into practice, demands a general acceptance of its ideals and purpose, is equally incontrovertible. How this is to be achieved, however is less easy to see. He admits that it requires first and foremost, the education of those affected to an appreciation of its benefits and a willingness to subordinate their individual idiosyncrasies to

the good of the whole. Unfortunately, there are so many conflicting views as to what constitutes the greatest good of the whole that the prime problem of securing agreement on this point alone presents almost superhuman difficulties, even if means and authority can be found to subdue the "recalcitrant minorities" which are unavoidable under any constitution that not merely permits, but encourages individual freedom of thought and speech. Not even a broader education of the engineering fraternity as a body in the humanities and in the literature of social and economic problems is likely to reduce this difficulty materially, for engineers are not a numerous section of the populace. It is suggested, as it has been suggested many times before, that they should extend their influence by training themselves for political action in a wider sense; but the engineer who turns politician or administrator usually ceases in practice to be an engineer, for the good reason that any one of these occupations, properly pursued, is a full-time task.

Granting, however, that this preliminary obstacle can be overcome, there still remain the major difficulties of establishing a "new order," based on the principles outlined by Mr. Beard, and of maintaining it when it has been established. He takes it as assured that "the day of small organisations and free competition is rapidly passing," and (in spite of his earlier warning against the danger of "vast bureaucratic organisations") declares that "modern economic and industrial development demands inexorably the organisation of both production and distribution on an ever-increasing scale, accompanied by the elimination of wasteful competition and a wider extension of monopolistic concerns," the profit motive being abandoned, and its place taken by a competition in results. How any such enterprise is to be successfully conducted is not obvious, in view of the fact, to which Mr. Beard himself draws pointed attention, that failures at the top can take place, and continue to take place, in a Government department or a large public concern, without disaster to the administration itself, however unfortunate the effect upon the community. Failure of such organisations as he visualises can only be avoided by financial support on a national scale; and if private enterprise, competition and profit are to be abolished, it is more than a little difficult to see whence the financial support is to be derived, without introducing other, probably undesirable, changes of an even more fundamental character. The prospect of a nation enslaved to a vast machine is not enticing, even though the slavery may be entered into voluntarily.

A crucial factor in the whole problem, and one to which Mr. Beard does not allude, is the circumstance that no nation can now exist as a separate and self-contained unit; and, unless all other nations can be persuaded to plan and organise their affairs on reasonably parallel lines, inspired by similar ideals and under the direction of equally efficient and high-souled supermen, the balance must be inevitably upset—if it can be achieved at all.

By all means, let us plan for the future; but the planning must pay due regard to the present and, especially, to the past. The present holds only one task—not the overthrowing of "old orders" at home, but the complete and utter defeat of the enemy without. Nazism is not an ideal that is pursued for its own sake, but a tool fashioned by a master spell-binder as a means to his own ends. So far as this country is concerned, it may be admitted—it must be admitted—that there were many deficiencies in the standard of life that had been attained up to the outbreak of war. Some of them were in process of being made good, though others—slums, unemployment, and inequalities between production and distribution, for example—were yielding only slowly to the efforts that were being made to cope with them; but the fact remains that, for the average man, possessing neither particular influence nor outstanding ability, but prepared to do his fair share of the work that is the lot and heritage of mankind, this country was better worth living in than any other in Europe, and perhaps in the world; and if an equal standard can be assured when the war is over, this generation will have no need to fear the judgment of posterity on its motives or its abilities.

AIR-RAID DAMAGE AND MUNITIONS PRODUCTION.

Broadly speaking, the strategy of the aerial warfare between Germany and her ally, and Britain, exhibits two principal phases. In one of these the machines have been used as auxiliaries to the ground or sea forces, for reconnaissance purposes and as a means of transporting offensive weapons, which can thus be used with great freedom against the opposing navies, armies and even the civil population. The Germans have exploited this method to the full, and it will be admitted that, from a purely military point of view, its value has been proved by events in Poland, Holland and France.

In the other phase, aircraft are also employed as destructive weapons; not, however, so much against the enemy's own fighting forces as against his land, sea and air communications, and especially against those industrial resources upon which his supply of munitions depends. It is this phase that we ourselves are now employing to the full, selecting targets the destruction of which will impede the enemy's war effort. That this policy, too, has not been lacking in success is shown by the reports of the condition of Hamburg, which has now virtually ceased to be a centre of production. For his part, the enemy, in his attacks on this country, has adopted the opposite view and in so doing has clearly shown his ignorance of the psychology of the British race. The result is that while by his constant raids he has exposed a number of innocent people to a great deal of unnecessary suffering and inflicted some thousands of casualties on men, women and children, he has, as Mr. Herbert Morrison recently pointed out, failed to reduce our productive capacity even temporarily by more than a small fraction of 1 per cent.

From a military point of view, we may, therefore, congratulate ourselves, both on adopting the more correct policy, and that, thanks to the efforts of the Royal Air Force, the enemy's contrary ideas have been proved to be fallacious, both in theory and practice. There is, however, another side to the picture. Though the damage that has been done to our factories and communications by indiscriminate bombing, considered from the material point of view, is small, it is not negligible. Moreover, it is by the nature of things more evident in London and South-Eastern England than in any other part of the country. How important this is is shown by the fact that this area is inhabited by something like a quarter of our population, and includes about the same proportion of the productive capacity of the industries which supply our munitions, using that term in its widest sense. Not only is this the case, but because the locality of London, as regards liability to bombing is so vulnerable, there are problems, among which transport is obviously one, which are not met with so acutely elsewhere.

How best to repair the damage to our productive capacity that has been caused by enemy action in this area is, therefore, rightly receiving the closest attention of the London and South Eastern Area Board. This Board, which is duplicated by others of the same nature in the rest of the country, comprises representatives, both of employers and of the trades unions, as well as of the Ministries concerned with aircraft production, naval construction and repair, and the needs of the army. Labour problems are looked after by the divisional controller of the Ministry of Labour, and the export trade by a representative of the Board of Trade. Moreover, there is liaison with the Industrial Capacity Committee, of which the Area Boards in the country are a part, and through this committee with the War Cabinet. Finally a representative of the Minister of Transport has recently been added, since, in the London area at least, the maintenance of easy and rapid communication between the workers' homes and places of employment is an important part of the problem.

It may also be pointed out that one of the duties of these Area Boards has been to examine the machine tool census which, as is well known, takes place at regular intervals, and in this way to find means of using spare capacity of tools and premises to see that labour is used in the most productive way, and particularly to make alternative arrangements which will ensure that industrial capacity is commensurate with industrial requirements when premises become partially damaged or disabled as the result of enemy action. It is in this connection particularly that transport is important. While it may be possible, even relatively easy, to arrange for the work of an essential factory to be carried on, at least temporarily, in one that is not so essential a few miles distant, such a transfer imposes disabilities on the workpeople, which are not willingly borne and which they can hardly be expected to bear. There is evidence that this is a point which employers sometimes tend to forget under the pressure of other work, and, if the Board can do anything to relieve the situation in this respect, they will have done much towards justifying their existence. The Board has also undertaken the task of arranging for the replacement of such precision tools as are the workers' personal property.

It will not be denied that if production is to be maintained under "Blitzkrieg" conditions, some organisation, which will operate speedily and efficiently, and we had almost said with due disregard for rules and regulations is required. It remains to be seen whether the arrangements which the Board has made fulfil these conditions. Actually, what has been done is to set up nine "clearing centres," seven in London and two in the South Eastern area, to which those in need of help can refer and which can, in turn, invoke the assistance of their fellows. So far these clearing centres have been mainly concerned with engineering firms, and in particular have designed rather elaborate machinery for classifying the machine tools available. In this way, it is hoped that the possibilities of idle tools or idle labour will be eliminated, and the best and most economic use of the reserves will be secured. It is proposed to extend their labours by organising such reconstruction of damaged premises as may be necessary after the emergency service designed by the Ministry of Aircraft Production has operated. It will, it is hoped, do this without duplicating the work of other departments, though, of course, it will work in the closest conjunction with them.

We have been asked to assist in this potentially useful work by making the nature of the operations of the Board known and by emphasising the services which it can render to industry as a part of the Industrial Capacity Committee of the Production Council. We have also been asked to point out that the Board is not a Committee for debating purposes, but has real executive functions which it will exercise for the benefit of both employers and workers. The sudden emergencies that may arise through enemy action have entailed losses which must be made good. The Board's main function is to minimise this waste and to render active and prompt assistance in the national war effort.

It need hardly be said that we willingly comply with this request. Victory may well go to the side which has the greatest resources, but care must be taken to utilise those resources in the most efficient way. There is no doubt which side fulfils the first of these conditions, but there may still, rightly or wrongly, be some lingering doubt as to whether the second essential is being met in the way that it should be. Though we were certainly second in the race of building up our munitions supply when war started, the machine was almost criminally slow in speeding up and there are still indications that what is sometimes called the Civil Service mind still bulks too large in dealing with the situation. This is no time for the reference of urgent matters to the consideration of committees, however distinguished their membership, especially when those bodies can do little more than recommend appropriate action to some Government department. That such procedure should still be followed is an indication that there is even now reluctance on the part of those who should do so to assume responsibility for taking action. While, therefore, we commend the work that the Area Board is doing both on the score of its value and its necessity, we must add that unless our productive capacity is to be slowed down immediate action in the face of emergency is essential.

NOTES.

NATIONAL SURVEY OF SCRAP IRON AND STEEL.

THE Iron and Steel Control of the Ministry of Supply has now issued a summary of the results of the first month's test-survey of the National Survey of Fixed and Demolition Scrap Iron and Steel. During the first four weeks of the survey, which was inaugurated on September 24, a total of well over 20,000 tons of scrap has been recorded as available in the counties of Somerset and Glamorgan, this amount being practically all the existing convertible material. The survey is now being extended to the whole of Scotland and the counties of London and Middlesex, while other areas will follow as rapidly as the work can be organised. The first test was intended to determine both the effectiveness of the methods of the survey and the tonnage and type of material available, and may be regarded as successful. The order in which the other areas just referred to will be dealt with depends upon such factors as the dismantling and transport facilities in relation to the needs of the steelworks in the immediate vicinity. Selection is being made according to the type of metal most urgently required by the steelworks, the material that can be collected and recovered most easily and economically being naturally dealt with first. Typical sources of scrap are disused steel towers and cables for overhead conveyors, railway lines in worked-out mines and quarries, mine buildings and machinery, accommodation bridges, and factories no longer in operation. Certain lengths of railway now not needed can be dismantled and a further source lies in buildings damaged by enemy action. We are glad to see that the summary, when referring to old pumps, beam engines, windmills, waterwheels, and the like, embodies a recommendation that discretion be exercised before dismantling, since a number of such installations are certain to have an irreplaceable historical value. As the Ministry of Mines is giving unstinted collaboration, however, its inspectors may be relied upon in their survey of abandoned mines and derelict collieries to exercise the necessary discrimination. The officials responsible for the survey estimate that at least 500,000 tons of scrap should be available from the whole country.

THE WAR AT SEA.

Hard upon the news of the gallant action of the armed merchant cruiser, H.M.S. Jervis Bay, which sacrificed herself, though not in vain, in protecting her convoy against the attack of an enemy surface raider on the night of November 5, there has come a most heartening account of the operations of the Fleet Air Arm against an important section of the Italian fleet, ensconced under the protection of the shore defences at Taranto. The attack took place on the night of November 11-12, and its results, as established by subsequent photographic reconnaissance, were announced some 36 hours later in an Admiralty communique. One battleship of the Littorio class was found to be so badly down by the bows that her forecastle was under water, and she had a heavy list to starboard. Another battleship, of the Cavour class, had been beached, and her stern was under water, up to and including the after turret, and she, also had a heavy starboard list. A second ship of the Cavour class probably suffered severe damage. In the inner harbour, two cruisers lay listed to starboard, and surrounded by oil fuel, and two fleet auxiliaries were lying with their sterns under water. That so successful an operation should have been carried through at a cost of only two aircraft is not the least remarkable feature. It appears probable, the Admiralty add, that some members of the missing crews have been taken prisoner by the Italians.

OFFICERS FOR THE R.N.V.R. AIR BRANCH.

The Secretary of the Admiralty informs us that well educated men are required for commissions in the Air Branch of the Royal Naval Volunteer Reserve for employment as pilots and observers. The age limits are from 18 to 28 and men who have not yet registered under the National Service (Armed Forces) Act, 1939, are eligible. Moreover, men who have registered under the Act and have expressed a preference for service in the Royal Navy or Royal Marines, but have not yet been posted for such service, and men who have registered under the Act and who have been allocated to the Army or R.A.F. but have not yet been attested for service in those Forces, are also eligible to apply. Applicants in this last category, however, should immediately notify the Ministry of Labour Office at which they have registered, that they now wish to serve in the Royal Navy. Their applications for the Fleet Air Arm cannot, however, be proceeded with if they are called up for service in the Army or R.A.F. before their selection for the Fleet Air Arm is finally decided. All applicants must have attained a general standard of education equivalent to that of the School Certificate and must have a knowledge of elementary trigonometry and mechanics. Furthermore, applicants will be required to pass a medical test requiring a high standard of physical fitness. Men selected for training as pilot or observer in the Fleet Air Arm will be enrolled in the first place, in the rating of Naval Airman 2nd Class and they must be prepared to serve either as pilot or observer as required. Those who satisfactorily complete the full course of training will be granted temporary commissions in the Air Branch of the Royal Naval Volunteer Reserve. Candidates should apply for further particulars to the nearest Combined Recruiting Centre, the address of which can be obtained from the local office of the Ministry of Labour and National Service, or in writing, to the Secretary of the Admiralty (C.W.514), London, S.W.1.

THE EXTENSION OF SUMMER TIME.

The Home Secretary has announced that the Government have decided to continue Summer Time during the winter instead of, as previously laid down, making the change back to Greenwich time on Sunday, November 17. In recording this decision, one commentator remarks that this will mean a valuable extra hour for business houses and shops, while for the public generally it will make the long winter nights a little less depressing. By a convention, which is as flattering as it is ill-founded, all readers of daily papers are presumed to live a life of luxury and ease. Were this true, they would naturally welcome another hour of daylight in the evening. Actually, of course, most of them, especially at the present time, have to be at work at a comparatively early hour in the morning; whereas the effect of the new procedure, especially during December and January, will be that they will not only have to get up in the dark, but may have to travel in the dark for an appreciable proportion of their morning journeys to work. It may be admitted that, in choosing between two evils, probably the lesser has been selected; but inconvenience and discomfort will continue to exist, and may even be increased, by thus stretching Mr. William Willett's original conception. It will be interesting to see what the effect will be on transport, and especially on electricity supply undertakings. Some revision of time tables may be found desirable, if not essential, if the public are to arrive at their places of work with less delay than was the common experience last winter. Even under the quietest conditions, the operation of an intensive service under black-out conditions is not easy. It is certainly not likely to be facilitated if the "alert" persists to a later and later hour. Electricity supply undertakings, too, will probably be faced with the problem of the morning peak in an exaggerated form, as upon the usual industrial and breakfast loads there will be imposed extra demands for lighting and especially for heating.

THE ARMS OF THE INSTITUTION OF MECHANICAL ENGINEERS.

On page 397 of this issue we reproduce the new armorial bearings granted to the Institution of Mechanical Engineers by the College of Heralds, under Letters Patent dated October 17, 1939. It may be conceded that the device, or collection of devices, formerly used by the institution as its seal was neither adequate as an indication of its status, nor heraldically orthodox, but we must confess to some feeling of disappointment regarding the coat which has now taken its place. With the general plan of its symbolism, there is no fault to be found; the deficiency is rather in the means by which it has been expounded and the relative proportions of the component parts in Mr. Cecil Thomas's design. The supporters are unduly tall in relation to the size of the shield, which is dwarfed also by its tapering superstructure of tilting helm, globe, and "forcene" horse—the latter presumably symbolising horse-power (though this is not stated) and apparently shod on its hind hooves only. The figure of Vulcan has strength and dignity, but the style of hairdressing affected by Archimedes seems inappropriate to a philosopher. His air of melancholy may reasonably indicate some philosophic doubt whether the use of callipers to measure the diameter of a "plate" is quite consonant with the "Progress" proclaimed on the scroll beneath. The whole design is oppressed by the extravagant mantling that forms canopies over the supporters and confuses the construction of the helmet. To criticise the more recondite details of the heraldry requires an expert knowledge to which we cannot pretend, but the general effect is something on which anyone may have an opinion, whose attention the coat of arms is intended to attract. Frankly, the arrangement portrayed does not appeal to us as the best that could be accomplished with the given components; and, while it may savour of the impious to criticise adversely the considered product of the College of Arms, the selection of devices, crest, supporters and motto suggests a type of municipal heraldry that seems somewhat out of keeping with a technical institution, the requirements of which would have been more suitably met by a coat of arms of the kind usually associated with centres of learning.

FIRE RISKS AT ELECTRICAL SUBSTATIONS.

In a circular addressed to the electricity supply undertakings throughout the country, the Electricity Commissioners emphasise the necessity for the closest collaboration with the local fire brigade services in order to ensure the promptest action whenever a fire occurs, either on the undertaking's own premises or at factories, warehouses, hospitals and other buildings which are supplied from substations on or near such premises. The steps which should be taken to obviate or minimise fire risks in generating stations and main substations, together with notes on fire-fighting appliances and equipment, are contained in the Report of the Fire Risks Investigating Committee, which was circulated in March, 1938, while in May of this year it was recommended that when danger notices on substations were obliterated or removed the whereabouts of such station should be notified to the fire brigade. It is now pointed out that it is equally important, under the present conditions, that there should be the closest co-operation in regard to substations on consumers' premises, and that the consumer also should be thoroughly familiar with all the precautions which have been taken to protect the substation against the risk of fire and with the steps which are necessary to cut off the supply of electricity to his premises should occasion arise. The Commissioners accordingly urge that undertakings which have not already done so should make arrangements with consumers, having substations on their premises, for the appointment of an authorised person who would have access to the switches controlling the supply of energy to the premises in case of fire or other emergency. They also suggest that opportunities should be given to officers of the local fire brigade to make themselves familiar with the lay-out of such substations and with the location of the fire-fighting equipment with which they are equipped. They should also be kept informed of the whereabouts of the authorised persons in charge of the keys of such substations and entitled to operate switches therein. The authorised person or officer in charge of the fire brigade should be advised to communicate at once with the undertaking, asking for the isolation of the high-voltage supply, if either of them for any reason should consider it necessary that this supply should be cut off from the substation. To facilitate the work of the fire brigade, it is important that the undertakings should not relax any safety precautions either as regards electrical risks or criminal interference. Any cases of difficulty under these headings should be reported to the Commissioners.

THE LATE SIR CHARLES L. MORGAN, C.B.E.

By the death of Sir Charles Morgan, on Saturday, November 9, the railway world has lost one of its distinguished figures and the Institution of Civil Engineers one who joined its ranks 57 years ago and ultimately, in 1923, attained the position of President. As Sir Charles was 85 years of age at the time of his death and retired from his position as Chief Engineer of the London, Brighton and South Coast Railway in 1917, it may be said that his work was done. It is but of the order of nature that the old prominent figures should, one by one, disappear, but that does not lessen the regret that will be felt at their passing. Sir Charles, however, has left a record which will continue to stand high in the history of railway development and civil engineering.

Charles Langbridge Morgan was born at Worcester on New Year's day, 1855, and after education at private schools in Australia and England, became a pupil of Mr. Edward Wilson, M.Inst.C.E., in his consulting practice in Westminster. This brought him into touch with railway matters from the first, and during his pupilage, which extended from 1870 to 1874, he was engaged on various works on the Great Eastern Railway. For the latter half of 1874 he was resident engineer on the East Norfolk Railway and for the first half of 1875 was engaged on the preparation of working drawings for the Banbury and Cheltenham Railway. For about twelve months he was resident engineer on the Cromer extension of the Great Northern Railway. By this time he had begun to establish his position in the civil engineering world, and, in 1876, he set up a consulting practice on his own behalf. His office was in Bristol, and in the course of the next two years he carried out various sewerage, tramway and railway works, one of his main commissions covering 150 miles of the Great Eastern Railway northern extension. In 1878, however, he rejoined the staff of E. Wilson and Company, successors to Edward Wilson, and acted as resident engineer on the Alexandra Park and Chingford branches of the Great Eastern Railway and on the Cheltenham section of the Banbury and Cheltenham Railway, with which he had been connected in 1875. He ultimately became chief engineering assistant to his firm.

It was in 1883 that Sir Charles, finally leaving consulting practice, became a railway official. His first appointment was that of chief assistant to John Wilson, the chief engineer of the Great Eastern Railway for construction and maintenance. He retained this post for 13 years, but by that time had so established his position in the railway engineering world that he was appointed chief engineer of the London, Brighton and South Coast Railway and of the Newhaven Harbour Company. This post he occupied for 21 years until his retirement in 1917. During his tenure of this position he was responsible for many important works on the railway, one of the largest being the construction of the new line from Stoats' Nest to Earlswood, which gave the company its own route to Brighton independent of the South Eastern Company's lines. The amalgamations which resulted in the creation of the Southern Railway took place so many years ago that the keen rivalry which used to exist between the Brighton line and the South Eastern may almost be forgotten. The complete reconstruction of the Brighton side of Victoria station, which constituted one of Sir Charles' major works, was, to some extent, further evidence of this rivalry, although the rapid building up of the suburban areas which the railway served was the preponderating influence.

The electrification policy which has been carried through with such thoroughness by the Southern Railway, was initiated by the Brighton Company, under Sir Charles' regime in 1909. His connection with this important work continued after his retirement from the post of chief engineer, as that event was marked by his election to a directorship, and it may be assumed that his great engineering experience and detailed knowledge of the railway made him a valuable member of the board; the fact that he was elected a director of the Southern Railway on the amalgamation of 1921 is evidence of this. Sir Charles held the rank of Lieutenant-Colonel in the Territorial Army, and during the war of 1914-1918 was detailed for special engineering duties for the War Office. These took him to Italy and France immediately after his retirement. For these services he was created a C.B.E. in 1918. He was knighted in 1923, the year in which he was chosen as President of the Institution of Civil Engineers.

Sir Charles' railway interests were fully displayed in his presidential address to the Institution. With a wealth of statistics, he traced the development of communication in the London area, with which he had been so closely associated professionally. Beginning with the Paddington to Farringdon line of the Metropolitan Railway, which was opened in 1863, he carried matters down to the opening of the Central London Railway in 1920. His account naturally covered the beginning of electrification of

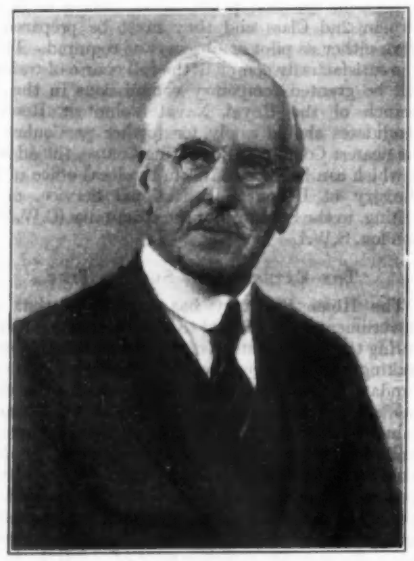


Photo: Lafayette, Ltd.

THE LATE SIR CHARLES L. MORGAN, C.B.E.

the London, Brighton and South Coast Railway, but his subject was transport development in London itself, rather than in the suburbs. Thus, his account covered omnibuses and tramways, as well as railways. He concluded with a hopeful message to the junior members of his profession, pointing out that although the difficult period following the Great War had led to disappointments and to the postponement of many large works, there was no reason to suppose that the days of great engineering works were over. In his later years, Sir Charles will have known that the enginee ing profession was well able to survive the aftermath of the war of 1914-18, and his practical sense and great experience will also have told him that it will do the same thing after the new war now ravaging the world. Sir Charles joined the Institution of which he finally became president, as an associate member in 1883, and was transferred to the class of member in 1889.

LAURENCE J. KETTLE PREMIUM.—The Council of the Institution of Civil Engineers of Ireland awards the Laurence J. Kettle Premium annually for a paper or thesis on a specially selected subject. The Premium consists of the Laurence J. Kettle Plaque and a prize of 15 guineas, and the subject for 1940-41 is "A Scheme for Collecting and Recording the Measurement of Natural Phenomena in Ireland." Candidates must be either associate members or students of the Institution and not more than 35 years of age on January 1. Papers, which should bear a *nom-de-plume*, should reach the honorary secretary of the Institution not later than March 1, 1941. Further particulars may be obtained on application to the Registrar of the Institution, 35, Dawson-street, Dublin.

THE LATE MR. RICHARD PAWLEY.

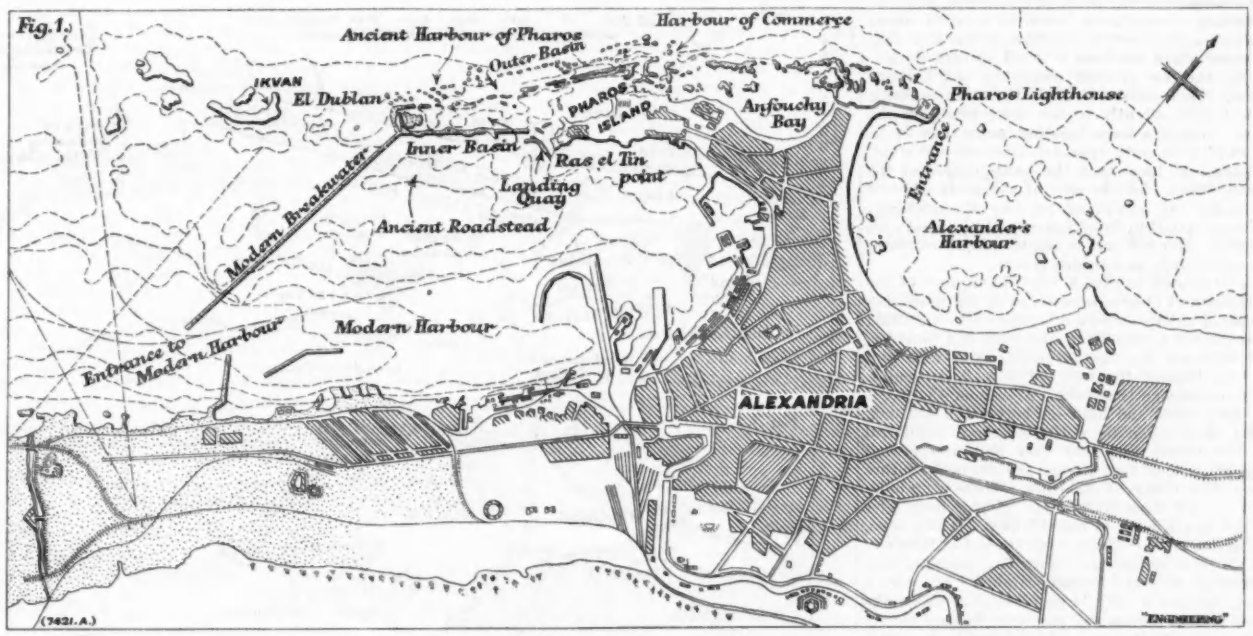
We have to record, with regret, the death of Mr. Richard Pawley, which occurred at a nursing home in Southport on November 8. Mr. Pawley, who was for many years chief engineer of the Hull and Barnsley Railway Company, was born on March 13, 1857. He received his general education at the City of London School, and, in December, 1873, when 16 years of age, was articled to Mr. William Hunt, M.Inst.C.E., engineer to the East London Railway. In January, 1876, he joined the engineering staff of the Lancashire and Yorkshire Railway, and was appointed assistant resident engineer on the Cheetham Hill and Prestwich extension of the line. In 1879, he was given full charge of these works, involving the construction of 8 miles of track, under Mr. Sturges Meek. In April of the following year he was appointed resident engineer, under Mr. Meek, of the Farnworth Tunnel widening works, and from May, 1881, until the end of 1884, was responsible, under his old chief, Mr. William Hunt, for the reconstruction of Victoria station, Manchester, of the Lancashire and Yorkshire Railway. Mr. Pawley's next task, which was begun in January, 1885, was that of superintending the construction, under Mr. Hunt, who had now become the chief engineer of the Lancashire and Yorkshire Railway, of the Hindley to Pendleton extension. This section of line, 13 miles in length, which comprised four tracks and also involved the construction of 2 miles of branch lines, provided a new direct route from Manchester to Liverpool. It necessitated the building of 83 bridges.

Mr. Pawley's long association with the Hull and Barnsley Railway Company began in 1888, when, at the early age of 31, he was made chief engineer of the company, which had been incorporated in August, 1880, and was known as the Hull, Barnsley and West Riding Junction Railway and Dock Company until 1905, when the shorter title was assumed by Act of Parliament. He was responsible for many important civil engineering works, including the extension of the Alexandra Dock, Hull, completed in 1899; the building of the Wath branch railway, opened in 1902; and the construction of the Braithwell to Laughton Railway, completed in 1909. In 1906, he was appointed joint engineer for the construction of the King George Dock, Hull, which was constructed by the North Eastern Railway and the Hull and Barnsley Railway Companies, and was officially opened by H.M. King George V in 1914. Mr. Pawley was also responsible for the building of the Gowdall to Braithwell railway line, which was opened for traffic in 1916. He retired under the age limit in 1922, and it is of interest to recall that in this same year, on April 1, the Hull and Barnsley Railway Company was amalgamated with the North Eastern Railway Company. Final incorporation in the London and North Eastern Railway was effected in the following year, on January 1, 1923. Mr. Pawley, who lived in retirement at Scarborough for many years, was elected an associate member of the Institution of Civil Engineers on May 1, 1883, and was transferred to the class of member on January 15, 1889.

ROYAL SOCIETY OF ARTS.—The first meeting of the 187th session of the Royal Society of Arts was held at 1.45 p.m., on Wednesday, November 6, when the inaugural address was delivered by Sir Atul C. Chatterjee, G.C.I.E., K.C.S.I., Chairman of the Council. His subject was "Recent Social Changes in India."

LARGE FORCED-CIRCULATION BOILER.—An interesting boiler installation is in process of construction by Messrs. Combustion Engineering Company, Incorporated, 200, Madison-avenue, New York, U.S.A. It is a forced-circulation boiler designed for an output of 650,000 lb. of steam per hour at a pressure of 2,000 lb. per square inch and a temperature of 960 deg. F. The lay-out includes a convection-type superheater, to give a practically constant temperature with outputs from 480,000 lb. per hour to full load; a reheater, economisers and regenerative-type air preheaters. Circulation will be effected by three pumps, any two of which will be able to deal with all load conditions. The feed pumps will work with an inlet pressure of 475 lb. per sq. in. and a delivery pressure of 2,200 lb. per sq. in. The boiler will supply steam to a 25,000-kW turbo-generator, the exhaust steam, at a pressure of about 400 lb. per square inch, being re-heated to 750 deg. F. and then being passed to the mains supplying two low-pressure turbine units having a combined capacity of 76,000 kW, these units being also steamed from five existing boilers with a working pressure of 375 lb. per sq. in. It is anticipated that the topping installation provided by the new plant will reduce the power station heat rate from over 14,000 B.Th.U. per kilowatt-hour to between 10,000 B.Th.U. and 11,000 B.Th.U. per kilowatt-hour. The boiler is for one of the power stations of the Montaup Electric Company, U.S.A.

ANCIENT HARBOURS OF THE MEDITERRANEAN.



ANCIENT HARBOURS OF THE MEDITERRANEAN.*

By Sir Leopold H. Savile, K.C.B.

It is perhaps a good thing during times of great stress occasionally to relax and to turn our thoughts right away from the present struggle. Since harbour engineering has been the branch of our profession with which I have been principally associated for most of my career, I propose to deal with harbours, from the dawn of written history to the early days of the Roman Empire. It is well established that before 3300 B.C., the Egyptians built sea-going ships and that they made voyages to far lands to procure iron, lead, silver and other materials; and it is recorded on the Palermo stone that about 3000 B.C. King Seneferu built 60 great ships to go to the Syrian coast to bring cedar-wood for his works. The terminus of these voyages was on the Canopic branch of the Nile, where was situated A-ur or the Great Door. Little is known about this harbour. It was an inland port and probably had the disadvantages of that type, especially as it lay on the banks of an arm of the delta. The actual site is not known, but I refer to it because it is the earliest harbour of which I have found mention and because it marks the beginning of the harbour of Alexandria, which, I think, has the longest history of any harbour in the world. On the Alexandrian site, over a period of nearly 5,000 years, there have been four distinct harbour building periods—the harbour of A-ur, about 3000 B.C.; the great harbour of Pharos, soon after 2000 B.C.; the harbour of Alexander the Great, begun in 332 B.C.; and the modern harbour, which dates from A.D. 1870. The three last of these are shown in Fig. 1. The Great Harbour of Pharos (Fig. 2, page 396) was typical of the pre-Hellenic form of massive structure, far more massive than some of the great harbours of modern times. Its layout and the skilful use made of the configuration of the bed of the sea might have been the work of a modern harbour engineer. Egyptian history, curiously enough, has no record of this harbour. M. Raymond Weill attributes both its conception and its construction to the Minoan Cretans, who at that time were the greatest sea-faring power in the Mediterranean. It could not, however, have been made without the co-operation of the reigning Pharoah, possibly Senusret of the Twelfth Dynasty, a famous builder of colossal buildings typical of the Egyptian, Minoan, and Mycenæan civilisations of those early times. This gives us a date somewhere between 2000 B.C. and 1800 B.C.

The harbour was based at its eastern end upon the island of Pharos, and at its western on the rock of Abu Bakar. It also took advantage of the submerged ridge running from Marabout point to the north of Pharos, and of the shelf which sloped from this toward the deep sea. From the bay of Ras el Tin at the western end of Pharos to the Abu Bakar rock there is a deep pool, bounded on its northern edge by the submerged ridge. It was by surrounding this pool with breakwaters and piers that the great inner basin was formed. Seawards of this, another series of breakwaters, using the outer edge of the shelf, enclosed the outer basin. The two basins together formed a magnificent harbour about 300 acres in extent. The entrance to the harbour was on the south, and the approach channel crossed the submerged ridge by the Passe des Corvettes between the Ikvan and El Dublan rocks. Between these rocks, the southern boundary of the harbour, and the island of Pharos, not then joined to the mainland of Egypt, was a sheltered roadstead for ships making the entrance against the prevailing north-west wind.

On the right the entrance is flanked by a slightly-curved landing-quay running in a north-east-south-west line, founded on a firm mass of argillaceous sand in the shallow water off the end of Ras el Tin point. This quay was 525 ft. long by 46 ft. wide and 18 ft. to 20 ft. high, and was built of large rough-hewn blocks of limestone from the quarries at Mex on the mainland, carefully laid in courses and bonded with small aggregate and sand well tamped down. The top was paved with pentagonal flags 26 ft. long by 23 ft. wide, all of the same shape and forming a chequer-work. The walls were vertical, but the upper surface had a gradient of 3 per cent. No cement or mortar was used on this or on any of the quays or breakwaters. Jutting out from the end of this quay, and partly enclosing the harbour entrance, was a jetty about 426 ft. long, consisting of two parallel walls just over 41 ft. apart, closed at the end by a cross-wall. These walls were 7½ ft. wide at the top, and were built with a slight batter on each face. The space thus enclosed was filled with rubble and sand, and had no paving on the upper surface.

The main entrance of which this quay and jetty formed the eastern protection was 650 ft. wide. The south wall of the harbour was 2,300 ft. long, in a general east to west direction but its course was irregular because it was largely built up on a line of reefs which bordered the deep water of the inner basin. The upper parts of this wall were built of large, carefully-hewn blocks ranging from 8 ft. to 16 ft. in length, laid with great precision. Again no cement was used, but the joints were filled with small stones. At the main-entrance end of the wall was a short protective mole or spur, 360 ft. long by 65 ft. wide, the object of which appears to have been to form a sand-trap to prevent the drift of sand caused by the south and south-west winds from blocking the entrance to the harbour. The pavement of the southern wall is of interest because its pattern is typical of the pavements found in Minoan Crete and lends support to the view that the harbour was the work of Cretan engineers. It was composed of large slabs of stone, many 16 ft. long, laid so that the joints radiated from a centre. The southern wall ended at a point a short distance south-west of Abu Bakar. Thence ran two walls, each about 490 ft. long, one in a north and the other in a north-west direction, enclosing between them a triangular area of about 28,000 sq. yards. This space was filled in by large blocks of limestone and formed an immensely powerful breakwater, much of which is still in existence and can be seen under water on a clear day.

The most marvellous works of this harbour were, I think, the two great breakwaters that guarded the inner basin and the outer basin. The first started from the northern end of the triangular area just referred to and ran for 8,500 ft. in a straight line to the western end of Anfouchy bay. For its first 2,000 ft. it was built in the same way as the southern wall, except that the part bordering the Abu Bakar rock seems to have been filled in with dumped stone to form a solid mass. Then followed a length of 6,500 ft. which needed to be very strongly made. Two walls founded on firm argillaceous sand overlying the submerged ridge already mentioned, were built 130 ft. to 200 ft. apart. Each ranged in width at its upper surface from 26 ft. to 40 ft., and had a batter of 30 to 1, and each was protected by a substantial toe. Their height, judged from the remains that have been found under water, appears to have ranged from 20 ft. to 30 ft. The depth of water in the basin is unknown, but it may be estimated at 25 ft. to 40 ft., with considerably deeper patches in the pool of Ras el Tin. The walls were built of enormous blocks of stone, roughly hewn and coarsely laid. All of the space between the walls was filled with large blocks, forming a surface between 180 ft. and 250 ft. wide. The great width would enable defending parties to move rapidly to any part of the harbour during piratical attacks, while in normal times it was useful for drying and repairing sails and fishing-nets, weaving ropes, and so forth.

Running parallel to this breakwater, and about 650 ft. distant from it, was another of similar construction enclosing the outer basin, the entrance to which was by a passage through the inner breakwater a little to the north-east of Abu Bakar, between its single-wall and double-wall portion. Protection was afforded by two moles running in the same direction as the landing-quay and a protective mole guarding the main entrance. The whole of the inner breakwater formed an immense quay. Besides this, several jetties about 60 m. (197 ft.) long ran out from the outer breakwater, and nearly the whole of the south wall of the inner basin formed a broad quay, giving a total length of quay of about 10,000 ft. There was also a kind of dock, built out seawards from the outer breakwater, the purpose of which is not clear. It may have been another entrance to the harbour.

The remains at the eastern end of the harbour, bordering on Anfouchy bay, are not so easy to interpret. About 650 ft. from its end the great breakwater of the inner harbour was pierced by an opening 160 ft. wide and 525 ft. long. This small port had two entrances, one from the outer basin, and one direct from the sea, carefully protected by two in-curving breakwaters. Beyond the commercial harbour, the great breakwater continued for a short distance to the shallow water at the commencement of Anfouchy bay, where a north

* Presidential address to the Institution of Civil Engineers, delivered in London on Tuesday, November 5, 1940. Abridged.

and south cross wall closed the harbour. A very large area between the breakwater, the wall, and the shore of the island was filled in with large stone blocks, as at the west of Abu Bakar.

At the extremity of the point of Ras el Tin, near the main entrance to the inner basin, is a small island around which are the remains of other works, including a short mole which enclosed a small private dock—perhaps for the use of craft owned by the harbour authorities. This surmise is made the more probable by the fact that, slightly to the north-west, are the submerged ruins of a large building, more than 92 ft. long by 46 ft. wide, with approach channels and steps, which appears to have been the headquarters of the port management. To the east of the great harbour was a smaller one occupying the bay of Anfouchy. It also was protected by breakwaters and equipped with quays, but it afforded only a shallow depth of water and was used chiefly as a fishing centre.

I have attempted to give a brief description of the ancient harbour of Pharos, as revealed by the researches of M. Gaston Jondet, carried out between 1910 and 1915; and when the science shown in its layout and construction is considered, we must, I think, agree with him that it was, indeed, the work of a realistic genius. It may seem strange that, when Alexander the Great founded Alexandria and built his harbour in 332 B.C., he should have taken no notice of these wonderful works. The reason was that they had disappeared under the sea, and all that marked the site of the future city was a little village at Rhacotis. There is no more record of its fall than of its rise. Homer may refer to it in the fourth book of the Odyssey. If this is so, then its decline must be dated some time after 1000 B.C.

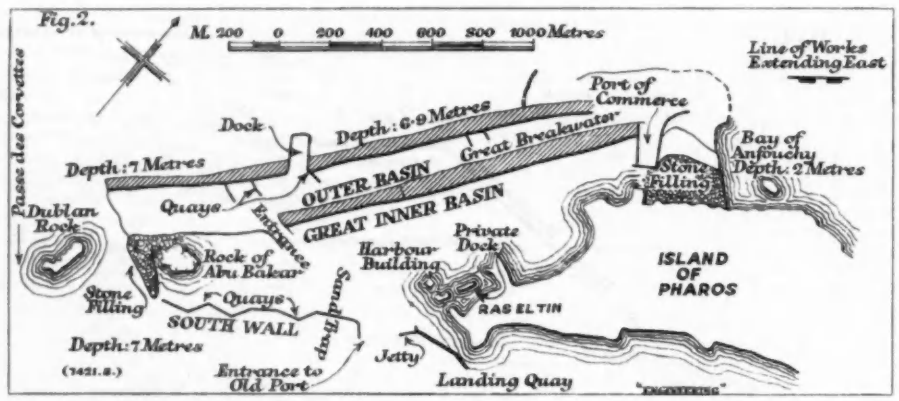
A few words as to the cause of its disappearance may be interesting, although "disappearance" is really a misnomer, because a very large portion of the works still exists and on a calm day parts can be seen clearly below the surface of the sea. The ridge of high ground upon which the harbour was built is formed of limestone similar to that exposed in the quarries of Mex. Overlying the slopes of this ridge is a thin layer of clay, upon which is a thick layer of river silt in various states of consolidation. Covering this on the higher slopes is the stratum of hard argillaceous sand, and it was upon this that the walls and breakwaters were built. M. Jondet considers that, as the silt consolidated, its bearing value weakened and the stratum of sand which rested upon it glided down the slopes in sudden subsidences, the underlying clay acting as a sliding surface. The process was purely mechanical, although earth tremors may at times have started the movement.

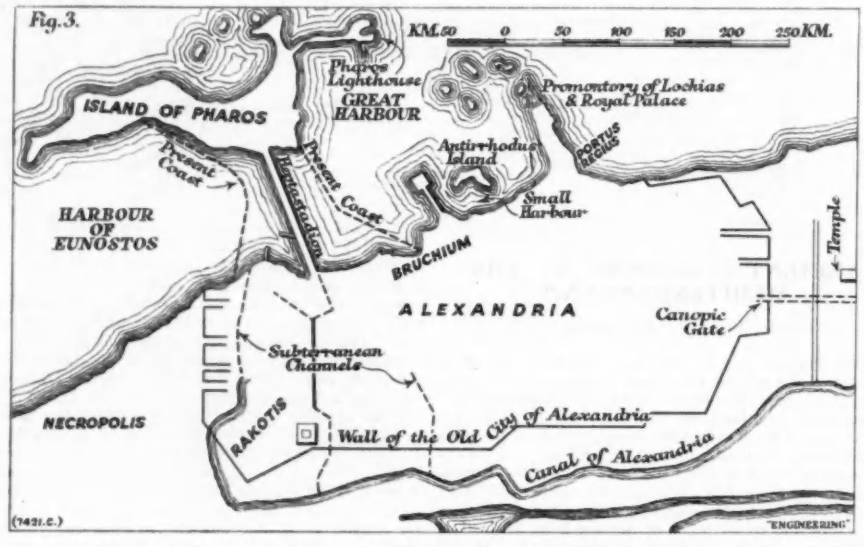
Fifteen hundred years after the foundation of the harbour of Pharos, Alexander the Great, returning down the Canopic branch of the Nile from the temple of Zeus Ammon, halted at Rhacotis. Ever since his destruction of Tyre he had determined to build a harbour that should be her rival. At Rhacotis he had found the place he wanted. He, himself, is said to have traced the plan of Alexandria and its harbour, which his famous engineer, Dinocrates, was ordered to carry out (Fig. 3). The main feature was the great mole, 600 ft. wide and 7 stadia (about 1 mile) in length, and hence called the *Heptastadion*, from the mainland to the island of Pharos, which divided the roadstead into two basins. It was built in a depth of water of 36 ft., and its construction entailed the excavation, transport, and deposition of about 2 million cub. yds. of stone. The basin on the right of the mole formed the Great Harbour, and that on the left the *Eunostos*, or Haven of Happy Return. Two openings through the mole connected them, thus conforming to the ancient rule that a harbour should have two entrances. The Great Harbour was bounded by the Lochias headland, the *Heptastadion*, and the eastern end of the island of Pharos. Seaward it was protected by a pier built out from Lochias and by a line of dangerous reefs, which made entrance to the harbour difficult. It was chiefly to remedy this that Ptolemy built the world-famous Pharos, or lighthouse, one of the Seven Wonders of the World, on the eastern point of the island. Alexander erred in putting his harbour in this place, since the depth of water was not so good as in the neighbouring haven, the reefs and Lochias pier did not provide sufficient protection against the winds, and the entrance was always difficult. Within the Great Harbour lies the small island of Antirrhodus, and between it, the mainland, and Lochias was formed a small *Portus Regius*, or port royal, for the king's ships. Between the *Portus Regius* and the *Heptastadion* the shore was lined with quays and storehouses. The public granaries were on the *Eunostos*, where also was a small inner harbour enclosed by piers. It was on this basin that the important canal connecting the harbours with lake Mareotis and the Nile, by its Canopic branch, opened. Alexandria partially fulfilled its founder's purpose of crippling the trade of Tyre; but this was due to the policy of Ptolemy Philadelphus (285-247 B.C.), who made a harbour at Berenice on the Red Sea, connected it with Coptos, on the Nile, by a road provided with water-places at proper stages, and re-opened the canal between the Nile and the Red Sea at Suez. Thus he captured for Alexandria the important trade of the Indian Ocean and the Red Sea.

A period of more than 2,000 years passes. In the meantime, the sand, which the engineers of ancient Pharos had been so careful to fend from the entrance to their harbour, had passed along the roadstead and had been caught up by the *Heptastadion*. Gradually it broadened until it formed that belt between the waters, upon which a large portion of the modern city of Alexandria is built. The engineers of 1870 discarded Alexander's great harbour, which had been for many years too difficult and shallow for shipping. They returned to the western side of Pharos and their great breakwater, like the south mole of the ancient harbour, was based on Ras el Tin. The modern harbour occupies what was the roadstead of its predecessor of 4,000 years ago.

(To be continued.)

ANCIENT HARBOURS OF THE MEDITERRANEAN.





WAR-TIME BUILDING CONSTRUCTION.

As will have been evident from the accounts which have been published from time to time in ENGINEERING, since the beginning of June the problem of how best to utilise materials as alternatives to steel in building construction is under consideration by a committee of the Department of Scientific and Industrial Research; and a number of pamphlets completing a survey of possible economies in the four commonest structural materials, steel, timber, bricks and cement, have been published. It now appears that the same subject is being dealt with, if from a somewhat different angle, by the Research and Experiments Department of the Ministry of Home Security, from whom we have received a *Bulletin* discussing single-storey war-time factory design. It is to be hoped that this does not mean an overlapping of activities since, important as the subject is, there is no room for this at present.

It is pointed out that while a main object of air attack is to paralyse production, this object can be neutralised by making factories highly resistant to collapse and difficult to fire. Of these, the latter is the more important, since up to the present far more steelwork has been destroyed by fire than by high explosives. The simplest way of minimising fire damage is, of course, to limit the combustible materials in the factory to the minimum essential. Correct planning can also play at least as great a part in minimising bomb damage as correct structural design. With this end in view, the tendency towards very large buildings which is so marked to-day should be reversed, for, in the event of a direct hit by a large bomb, all the glass and roofing material in the building, almost irrespective of size, will be destroyed, while even in a small building the explosion will be, to some extent, confined by the walls and roof. It therefore follows that it is preferable to sub-divide a factory into as many units as possible rather than to concentrate everything in one large building. This has the additional advantage of minimising the area likely to be destroyed by fire. Moreover, it may be possible to arrange production in several parallel lines so that if one link is destroyed it can be by-passed.

The *Bulletin* is mainly concerned with the principles of design applicable to a single-storey building, which is by far the most common type of factory for war-time production. The first principle is that all loads should be carried by a frame of steel or reinforced concrete, since load-bearing walls are dangerous. Little experience of the behaviour of reinforced concrete has, however, so far been obtained, though it is known that a member of this material is more severely damaged by a direct hit than a comparable one of steel. It may, therefore, be impossible entirely to eliminate collapse in reinforced-concrete frame buildings. The evidence so far available, however, suggests that where reinforced concrete is used, the most satisfactory way of minimising damage is to divide the framework into as many discontinuous units as possible, and thus to localise any collapse.

The second principle is that the steel frame should resist collapse notwithstanding the sudden removal of any one main member. This is not so rigorous as might appear. Near the explosion, the load is generally relieved by the roof covering being blown away and there have been a number of cases where direct hits have severed either the rafter or the main tie of a steel roof truss without producing a measurable sag. The chief risk to roof steelwork arises from the violent

displacement of a stanchion foundation and the consequent shearing of the stanchion cap connection, leading to the collapse of the roof trusses. This risk is eliminated if two simple precautions are taken. The cap connection of the stanchion to the roof member should be made stronger than is usual in order that it shall not be sheared off even if the stanchion base is shifted 4 in. or 5 in. This precaution is particularly necessary in the case of trusses or beams connected to external stanchions. In addition to the effects of ground movement, such stanchions are liable to be subjected to a considerable horizontal blast pressure which is applied to them by whatever wall construction is adopted. Provided their cap connections are adequate, however, the worst effect of this blast will be to bow out the stanchions without causing any major damage or collapse. In addition, the roof girder or valley beam should be spliced so as to be continuous. This will ensure that, even if a stanchion is destroyed, the valley beam is adequate to carry the dead load only of the roof without the sheeting over two bays. These precautions will not serve if two adjacent stanchions are destroyed, and a stanchion spacing of at least 30 ft. each way is desirable to prevent this. An explosion inside a factory forces the roof upwards and the steelwork should be designed to resist this by using angles rather than flats for all tension members and by such modifications in the roof covering as anchoring the slabs to the steel framework, linking them together, or making them continuous by providing an additional top reinforcement after they have been erected.

Generally speaking, the experience of recent air raids has indicated that the roof types recommended in *Wartime Building Bulletins*, Nos. 1 and 4,* are the best possible from the point of view of resistance to air attack provided they are fully steel-framed. Certain modifications in the type designs are, however, suggested and will be given in *Wartime Building Bulletin*, No. 10. For instance, a sheeted roof consisting of symmetrical roof trusses carried on valley beams will only collapse if a stanchion is destroyed. This danger can be eliminated by designing the valley beams so that they are strong enough to carry the dead load of the roof without the sheeting over two bays. The original design of sheeted roof, consisting of symmetrical umbrella trusses cantilevering on either side of apex lattice girders, is to be modified by strengthening the girders to enable them to act as continuous girders, to localise the collapse which might otherwise be caused by the destruction of a number of adjacent trusses in the same bay. The purlins may then apply an excessive pull to the neighbouring trusses, drawing them over and producing a spreading collapse. This effect can be guarded against by providing wind bracing at intervals in each bay.

The external walls of a war-time factory should be regarded simply as protective screens. They should not be built into the webs of the stanchions, but should be butt-jointed against the concrete or brick casing of the latter. Sheeting on steel framing should be fitted between the tops of the panels and the eaves, and both eaves and panels should be designed so that they do not transmit blast damage to the framing. The sheeting should be of asbestos cement or other brittle material protected by wire or sisal netting. The space above the dwarf walls may be glazed, preferably with a translucent flexible glass substitute. If glass is used, it should be protected by wire netting. The use of light-weight internal partitions to sub-divide a factory should be avoided. Substantial internal partitions can be designed to afford a considerable measure of protection. If they are built to the full height of the shop they will provide useful fire stops and may limit blast damage to the roof. They should be framed in steel or reinforced concrete and be independent of the main structure.

As regards roof covering, the little evidence so far available on the behaviour of flat roofs protected by a 4-in. reinforced-concrete slab under the effects of direct hits and near misses, indicates that they should afford considerable protection to the factory from debris; it may give some protection to plant from bombs which explode when they strike the roof. On the other hand, the effect of a large bomb exploding inside a factory is likely to be more serious. The slabs will undoubtedly be lifted and may fall into the shop, thus doing more damage than the bomb. The best safeguard, as mentioned above, is to anchor the slabs to the steel framework, the system being designed to withstand an uplift pressure of at least 100 lb. per square foot. Sheeted roofs are less subject to external blast than are walls. Corrugated iron is, therefore, the ideal covering. Asbestos-cement sheeting is about 15 times as liable to damage as corrugated iron, but its strength can be considerably increased by reinforcing it with fabric tape. Insulating boarded lining should on no account be used under sheeted roofs. Under a direct hit such a lining does not save the roof sheeting and causes extensive damage to the roof steelwork The presence of lining also results in an excessive uplift being applied to the steelwork and may cause very extensive damage to it.

A main cause of delay in returning to full production in bombed factories has been extensive damage to roof glazing, which has to be replaced before night work can be resumed. For this reason, it is desirable that roof glazing should be entirely eliminated from new factories. If it is considered essential to maintain natural illumination, the minimum amount of glass, or preferably of flexible glass substitute, should be used. Provided that wired glass is used and is supported by battens fixed between the glazing bars, it is possible that it may remain weatherproof under fairly severe blast. Nevetheless, wire netting should be fixed beneath the glass. Cast iron and other buried pipes for services should be isolated from the effects of ground movement by providing an air space round them either by laying them in ducts or guard trenches.

* See ENGINEERING, vol. 149, page 569 (1940), and page 25, *ante*.

GRANT OF ARMS TO THE INSTITUTION OF MECHANICAL ENGINEERS.

IN the Annual Report of the Council of the Institution of Mechanical Engineers for the year 1939, it was stated that a grant of armorial bearings had been made to the institution under Letters Patent from the College of Arms. The Royal Charter of Incorporation which was granted by the Crown in 1930 constituted

the Institution of Mechanical Engineers "one Body Corporate and Politic," "with perpetual succession and a Common Seal with power to break, alter and make anew the said Seal from time to time at their will and pleasure." By virtue of this authority, steps were taken to apply for these Letters Patent, so that the seal, arms, crest and supporters should be devised on correct heraldic principles. The accompanying illustration reproduces the emblazoned drawing by Mr. Cecil Thomas, who was commissioned by the Council to prepare the steel die for the seal.

The symbolism adopted is briefly as follows: On the shield, a device signifying the art of measurement and accuracy of workmanship; as the crest, controlled power dominating the world, typified by a heraldic horse chained to the globe from a coronet, which is itself a symbol of a chartered body; lastly, as supporters (to which the institution is entitled as a chartered body), a representation of Archimedes appears on the left, to signify science, and of Vulcan, on the right, to signify craftsmanship. The word "Progress," appearing below the shield, has been used by the institution on various of its devices and at different times since it was founded. The Council state that they were greatly assisted in the whole undertaking by one of their members, the late Colonel Sir George Willis, C.I.E., M.V.O., M.I.Mech.E., then Chairman of the Southern branch, who was an authority in heraldic matters.

In the words of the grant, the symbolism just given is thus described:

"Sable between the points of a pair of Callipers inverted Or a Plate and for the Crest on a Wreath of the Colours:—Upon a terrestrial Globe a Grey Horse forcene proper gorged with a Coronet composed of four Fleur-de-Lys with Chain reflexed over the back Or . . . : And by the Authority aforesaid I the said Garter King of Arms do further grant and assign the Supporters following, that is to say:—On the dexter side a Figure representing Archimedes holding in his exterior hand a Pointer and on the sinister side a Figure representing Vulcan resting his exterior hand upon a Sledge Hammer proper . . . the whole to be borne and used for ever hereafter by The Institution of Mechanical Engineers on Seals, Shields, or otherwise according to the Laws of Arms."

We comment editorially on the design on page 393 of this issue.

LETTER TO THE EDITOR.

MECHANISATION ON THE LAND.

TO THE EDITOR OF ENGINEERING.

SIR,—I thought your plea for a greater measure of standardisation in the manufacture of agricultural machinery so obviously sound as to need no comment. I am therefore completely at a loss to know what Mr. J. G. B. Sams has in mind when he claims, in your issue of November 1, that we already have a "reasonable amount" of standardisation "in the larger implements." If a farmer or contractor has ten-wheel tractors, not all of identical model and date of manufacture, he can be quite sure that no two pairs of wheels among them will be interchangeable. If he has ten ploughs, all nominally intended for the same type of work, he will have to quote the exact pedigree of each whenever he wants to buy spare shares or coulters, or even the clips which hold the latter in place; and these are probably the most highly standardised of agricultural machines. In the case of drills, mowers, binders and a host of others, it is doubtful whether even the nuts and bolts of two different makes or models will correspond.

As to the idea that this state of affairs is inevitable because of local variations in soil and conditions, I would point out that there is not a parish in the country which does not include satisfied users of implements designed and made overseas by men who have never even set foot on our soil. The country which first standardises its agricultural implements will be well on the way to capturing the export trade of the world, because its products will save farmers and implement dealers so much time and trouble that their appeal will be irresistible.

The question of co-operative working, which formed the other main subject of your article of October 18, is a rather more difficult one to discuss. It is, however, worth remembering that at the moment some 2,000 tractors and a host of associated implements all over the country are being worked, mainly for the benefit of small farmers, by County War Committees—that is by non-profit-making organisations virtually managed by representatives of the farmers themselves. This, in effect, is by far the biggest experiment in co-operative working yet made; and I see no reason why we should not derive from it the experience necessary for a workable peace-time scheme which will let the small farmer share the full benefits of mechanisation.

Yours truly,
S. J. WRIGHT,
Consulting Engineer to the Royal Agricultural Society of England.

10, Parks-road, Oxford.
November 4, 1940.

THE LATE MR. EDWARD WILLIAMSON.—We regret to record the death, which took place on November 6, at Hurlingham, of Mr. Edward Williamson, M.I.Mech.E., who was for more than 20 years London manager for Messrs. Manlove, Alliott and Company, Limited, Nottingham. He was 80 years of age, and had been living in retirement since 1936. Before joining Messrs. Manlove, Alliott and Company, Mr. Williamson was in business for many years in Hackney, as a maker of laundry machinery, and had been responsible for introducing a number of improvements in this branch of engineering. In 1902, however, he relinquished his own business on appointment as London representative for Messrs. Manlove, Alliott and Company, and, some eleven years later, on the resignation of Mr. H. B. Ransom, Mr. Williamson succeeded him as London manager. In this capacity he had been directly responsible for a number of important installations of laundry, heating and other plant, including the boilers, pumps and laundry machinery at the Royal Naval Hospitals at Chatham and Haslar, the King Edward Memorial Hospital at Lahore, the West Suffolk Hospital, and the Royal Air Force station at Cranwell. He was also closely concerned with the fitting of oil-fired galleys in various vessels of the Royal Navy, including H.M.S. Hood. He was elected an associate member of the Institution of Mechanicel Engineers in 1899, and was transferred to member in 1921.

LABOUR NOTES.

The Engineering and Allied Employers' National Federation gave their reply in London last week to the claims of the unions having members employed in the industry for increases of wages. As stated on page 368, *ante*, it was to the effect that the employers "could not accede to the applications." In the course of his reply, Sir Alexander Ramsay, Director of the Engineering and Allied Employers' National Federation, submitted, it is stated, a table showing actual earnings in the engineering industry and another table showing comparative earnings in engineering and other trades. The significance of the figures in the second table was that engineering workers were not in a disadvantageous position. From the table of earnings, it appeared that skilled men, who are working 5½ hours longer a week, are earning, on the average, 28*s.* a week more, semi-skilled men, working the same additional number of hours, 24*s.* a week more, and labourers, working rather less than five hours longer, 16*s.* a week more. These calculations, it was indicated, included the 5*s.* a week conceded in February last.

The executives of the societies of which the Confederation of Shipbuilding and Engineering Unions is composed, are to meet at York, on November 19, to consider the employers' reply. The executive of the Amalgamated Engineering Union may recall the National Committee for its opinion, as it was on that body's instructions that it put forward the claim.

The Ministry of Labour Gazette states that in the industries for which statistics are regularly compiled by the Ministry of Labour and National Service, the changes in rates of wages reported to have come into operation in September are estimated to have resulted in an increase of about 58,000*l.* in the weekly full-time wages of nearly 700,000 workpeople, and in a decrease of about 10,700*l.* in those of 340,000 workpeople. The workpeople, whose rates of wages were reduced, had received increases of greater amount during the earlier months of the year. The changes so far reported in the nine completed months of 1940 in the industries for which statistics are available, are estimated to have resulted in a net increase of about 1,760,000*l.* in the weekly full-time wages of about 7,725,000 workpeople.

The principal groups of workpeople whose wages were increased in September included coal miners in Yorkshire, Derbyshire, Nottinghamshire, Leicestershire, Cannock Chase and Somersetshire, drug and fine chemical workers, soap and candle workers, workpeople employed in the ready-made and wholesale bespoke tailoring trade, workpeople employed in the sugar confectionery and food-preserving trade, and distributive and transport workers employed by retail co-operative societies. The workpeople whose wage rates were reduced included coal miners in Northumberland and Scotland, workpeople employed in the iron and steel manufacturing industry in various districts, tin-plate workers, tobacco workers and coopers.

At October 1, the official cost-of-living index figure was 80 per cent. above the level of July, 1914, as compared with 87 per cent. at August 31. For food alone, the index figure at October 1 was 69 per cent. above the level of July, 1914, as compared with 66 per cent. at August 31. The rise in the index figures at October 1 was mainly due to increases in the prices of eggs; there were also increases in the prices of some kinds of fish, and the price of milk was raised in some districts on October 1. Among items other than food, the principal changes were increases, averaging between 1 and 2 per cent., in the prices of clothing.

The number of insured persons, aged 16 and over, officially recorded as wholly unemployed in Great Britain and Northern Ireland at September 16, 1940, represented 4·3 per cent. of the total number of persons between the ages of 16 and 64 insured against unemployment at July, 1939, as compared with 4·1 per cent. at August 12 and 6·9 per cent. at September 11, 1939. Among persons insured under the general scheme, the number wholly unemployed at September 16 represented 4·4 per cent. of the total number insured at July, 1939, as compared with 4·2 per cent. at August 12. Among persons within the agricultural scheme, the corresponding percentages were 2·2 at September 16 and 2·3 at August 12.

The number of insured persons, aged 16 and over, officially recorded as temporarily suspended from work on September 16, 1940, represented 1·3 per cent. of the total number of insured persons between the ages of 16 and 64 at July, 1939, compared with 1·1 per cent. at August 12. Among persons insured under the general scheme, the corresponding percentage was 1·4 at September 16, compared with 1·1 at August 12; among persons insured under the agricultural scheme, the percentage was 0·1 at both dates. The number of insured casual workers, between the ages of 16 and 64, officially recorded as unemployed on September 16, represented 0·2 per cent. of the total number of insured persons at July, 1939—the same as at August 12.

The number of trade disputes, involving stoppages of work, reported to the Ministry of Labour and National Service as beginning in September was 83. In addition, two disputes which began before September were still in progress at the beginning of that month. The approximate number of workpeople involved in these 83 disputes, including workpeople thrown out of work at the establishments where the disputes occurred, was about 21,000, and the aggregate duration of the disputes in September was about 52,000 working days.

Addressing a meeting of members of Parliament last week, Mr. Bevin, the Minister of Labour and National Service, said that the great development of war industries had made it impossible any longer to rely on voluntary efforts for the organisation of welfare work, and it had been necessary to issue a Welfare Order applying to factories and groups of factories employing more than 250 persons. An adequate supply of trained welfare officers had been already assured by payment of fees for the attendance of selected candidates at courses arranged by the universities. He believed that these welfare officers, picked for their personality and experience, would be regarded as ranking equally with the members of the factory staff responsible for production. Hitherto the workers had been protected, but in too many cases nothing had been done to promote their moral comfort and welfare. These would now be the responsibility of the welfare officer.

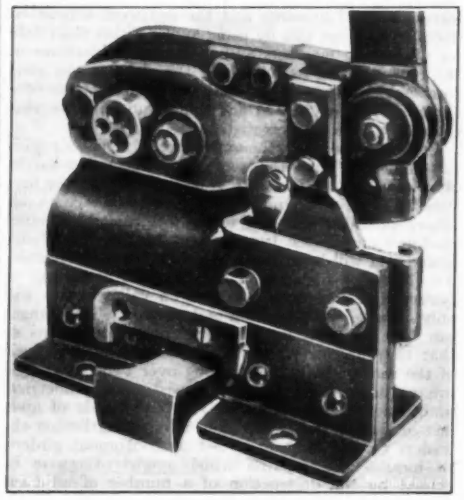
The Minister said that he hoped to keep factory welfare work distinct from local welfare activities. When a man had finished his day's work he liked to be independent and free of the discipline necessarily connected with his employment. There would, therefore, be other welfare officers appointed to encourage local organisations which provide means of recreation, relaxation, and amusement outside the factories. They would also assist in arranging for the suitable billeting of imported workers and for transport facilities to reduce the fatigue and discomfort of those whose homes were distant from the factory. The appointment of doctors experienced in problems of fatigue and psychology was another feature of the scheme, and a special course of instruction in industrial hygiene would be provided at the London School of Hygiene. The factory doctor was now recognised as an essential adjunct of works management.

Mr. Bevin told a meeting of factory workers in the Midlands last week that in another six months we should have passed Germany in aircraft, ships and guns, and prophesied that immediately we had accomplished that the world would move back to a peaceful time of reconstruction, the wiping away of privilege and the growth of knowledge. "Give us another six months' intensive production," he said, "and we shall have passed Germany, and the ugly Nazi regime will crumple up in Hitler's hands. I do not care how much bonus you earn. I will put my money on the British team, and the British team is going to win. I shall be visiting you again, and I shall not be talking of war, but of a great effort towards building a better civilisation."

A voluntary scheme organised by the Ministry of Labour and National Service, in which the methods of the National Safety First Association are applied in factories by the Factory Department of the Ministry, is now in operation. It has been specially designed to deal with aspects of the prevention of accidents in war time. In the course of a foreword to a pamphlet describing the scheme, Mr. Bevin says:—"It is the duty of the Factory Department of this Ministry to help industry to deal with the prevention of accidents, but the ultimate success of any scheme rests with the management of individual firms, acting in co-operation with their workpeople, through their putting into operation the preventive measures that are advised. I am glad to have the service and help of the National Safety First Association, who have had nearly 25 years' experience of the methods by which progressive firms reduce their accident rates. This pamphlet outlines a special scheme and I must have the co-operation of industry in making the best use of it. If the scheme succeeds in preventing even 1 per cent. of the accidents now occurring in industry, loss of production will be avoided and the money cost amply covered."

HAND-LEVER NIBBLING AND SHEARING MACHINES.

The hand-lever nibbling and plate and round bar shearing machine shown in the accompanying illustration is one of a range of three types recently introduced by Messrs. F. J. Edwards, Limited, 359-361, Euston-road, London, N.W.1. This particular machine is known as the Besco Model No. 3, and will shear mild-steel plates up to ⅛ in. thick, while mild-steel rods $\frac{3}{16}$ in., ¼ in., $\frac{5}{16}$ in. and ⅜ in. in diameter may also be cut with it. The machine as shown is arranged for straight shearing, with straight blades 3½ in. long, and as the frame is of mild steel bent off-centre, the sheared plate will pass it without difficulty so that there are no restrictions to the length or width of the plate that can be dealt with. It is also shown as used when bolted down to a bench or stand, though it can be held in a vice when desired. It is for this latter usage that the projection in the middle of the base is fitted, this projection being hinged so that it will fold down into a vertical position to go between the



vice jaws. In the figure, it is, of course, turned into the horizontal position so as to clear the bench top when bolted down. The hold-down seen in front of the blade is also hinged on its bracket. When not required, the vertical member is swung back out of the way round the upper bolt of the bracket, a slot being provided for the lower bolt, which functions as a lock.

When employed for nibbling plates which have an irregular contour, either round the outer edge or round the edge of a hole, such work as templates and trial blanks for stamping processes can be readily dealt with. The blade used for nibbling is shown attached, for convenience, to the base of the frame. One end, it will be seen, is shaped for outside nibbling and the other for inside nibbling. For the latter operation the cut is started by drilling a single hole in the work. The inside nibbling depth is 3 in., and the width of the blade is ¼ in. The blades are secured by two screws only, so that changes can be rapidly made. Rods are cut by insertion through the appropriate hole in the circular block seen to the left. Of the other two types of machine, Model No. 4 is the largest. It will shear and nibble plates up to $\frac{5}{16}$ in. thick, and cut rods of the same diameter as the machine just described. The inside nibbling depth is 3½ in. The smallest machine of the range, viz., Model No. 2, will shear plates ⅛ in. thick, but is suitable for outside nibbling only and has only a single hole for rod cutting; the hole will take a rod up to $\frac{5}{16}$ in. in diameter. The weight of the machines ranges from 18 lb. for the smallest size to 30 lb. for the largest size.

Timber for Motor Vehicles.—The Minister of Transport informs us that certificates to purchase hardwood and softwood required for the construction and repair of motor vehicles used for civilian purposes in this country, will, in future, be issued by Regional Transport Commissioners instead of, as at present, by the Headquarters of the Ministry of Transport. Applications for certificates should be made to the commissioner for the region in which the work is to be carried out. Hardwood and softwood required for motor vehicles for export will continue to be allocated by the Ministry of Transport, Metropole Buildings, Northumberland-avenue, London, W.C.2, to which address application for certificates to purchase timber for this purpose should be made. Plywood is still being dealt with by Area Timber Control officers.

THE MANUFACTURE OF STEEL BY THE PERRIN PROCESS.*

By B. Yaneske.

(*Concluded from page* 358.)

Experiments on the Method of Adding Ferro-Manganese.—The foregoing experiments showed clearly that although the blown metal could be successfully and rapidly dephosphorised by the Perrin process, the results, as far as carbon and manganese were concerned, were much too inconsistent, so that it did not appear possible to guarantee the manufacture of steel to chemical specification by the method so far tried out. The author, therefore, decided to conduct a series of experiments with the object of discovering the most satisfactory method of adding manganese to the steel.

In addition to experiments Nos. P3, P6, P7 and P8, a few more experiments on the method of adding ferro-manganese cold to the blown metal before dephosphorising were carried out. Similar unreliable results were obtained, and the control of the analysis was found to be impossible, the manganese in the finished steel, in all the experiments under this heading, varying from 0·14 per cent. to 0·51 per cent. Except in the case of heat No. P6, excessive oxidation of manganese was the result, even in the presence of at least 15 per cent. of MnO in the slag, which, of course, necessitated the addition of a considerable quantity of manganese ore to the slag—a costly procedure. This method was, therefore, considered to be entirely unsatisfactory.

The result of an experiment on a method of adding ferro-manganese in a molten state to the dephosphorised blown metal through the slag was remarkable in that the whole of the added manganese was abstracted by the synthetic slag, notwithstanding the presence of 9·6 per cent. of MnO in the slag. Sufficient molten ferro-manganese was added to yield normally 0·40 per cent. of manganese in the finished steel, but only 0·10 per cent. was found in the pitside ladle samples on analysis, which was about the same percentage of manganese as was present in the dephosphorised blown metal before the addition of the molten ferro-manganese. Moreover, rephosphorisation occurred, for, whereas the phosphorus in the dephosphorised blown metal was 0·031 per cent., as much as 0·105 per cent. of phosphorus was found in the finished steel. This method, therefore, was ruled out of further consideration.

A method in which ferro-manganese was added cold to the dephosphorised blown metal, after pouring off the dephosphorising slag, was found to be successful so far as the introduction of manganese into the steel was concerned, for the analysis of the finished steel was found to be uniform throughout the cast, ladle samples, taken when casting each ingot, having carbon and manganese contents between the limits of 0·09 per cent. to 0·10 per cent. and 0·47 per cent. to 0·49 per cent., respectively. The loss of manganese was a little over 40 per cent. The objection to this method, however, was that the steel in the casting ladle skulled badly, so that the ingots did not cast satisfactorily, owing to the loss of temperature incurred during the time taken to pour off the slag after dephosphorisation and to the absence of a sufficient quantity of hot slag covering the steel in the ladle during the casting of the ingots.

Several experiments, in which the addition of red-hot lump ferro-manganese was made to the dephosphorised blown metal through the slag, were conducted. The results were very consistent, and the composition of the finished steel was always within the chemical specification aimed at. The manganese was also found to be uniformly distributed throughout each cast and the loss of this element averaged about 35 per cent. In order to carry out these experiments, a roasting furnace fired by coke-oven gas for heating up the ferro-manganese to a red-hot condition was installed at the side of the blown-metal pouring trough on the furnace platform. The required weight of ferro-manganese, in pieces of 3 in. to 4 in. size, was charged in the roasting furnace, which was tilted at an angle towards the pitside and had a chute attached which directed the alloy into the casting ladle. As soon as the dephosphorising reaction had subsided, the ferro-manganese lumps, which had been made red-hot in the meantime, were pushed with a rake down the chute and dumped into the casting ladle through the slag. Five minutes were allowed to elapse for the alloy to dissolve and the resultant steel was then cast into ingots. After very good results were obtained with several heats, it was decided to adopt this method of adding manganese to the steel as standard procedure for future experiments.

In order to observe the effect of the quantity of synthetic slag used on the extent of the dephosphorisation, several experiments were conducted with smaller quantities of slag than were used in previous heats. In a first experiment, the quantity of slag used was only 5¾ per cent., which was evidently too little, for the percentage of phosphorus in the finished steel was on the high side of the specification. The result, however, showed the possibility of regulating, to some extent, the phosphorus content of the steel by employing different weights of slag. There was a satisfactory yield of manganese, which was evenly distributed throughout the cast. The total loss of manganese in this experiment was 36 per cent. The ingots were rolled into tin-plate bars, which had an excellent appearance. The bars were subsequently rolled into tin-plate with satisfactory results.

The amount of slag used in a second experiment was a little over 6½ per cent., and the percentage of phosphorus in the resultant steel finished within the chemical specification. The yield of manganese was satisfactory, and this element was uniformly distributed throughout the cast. The total loss of manganese was 35 per cent. The ingots were rolled into tin-plate bars which had an excellent appearance. The bars were subsequently rolled into tin-plate with satisfactory results.

A review of the information gained from the results of experiments on the dephosphorisation of steel by means of the Perrin synthetic slag suggested to the author the possibility of employing molten basic open-hearth furnace slag for dephosphorising purposes, particularly slag with a high iron-oxide content taken from the tilting furnace directly after tapping low-carbon rimming steel heats made by the duplex process. Therefore, a series of experiments was conducted with basic open-hearth furnace slag, and the chief particulars of three such experiments are given as typical examples of the results obtained.

*Heat No. P*69. *September* 11, 1937.—The object of this experiment was to dephosphorise two blows from the Bessemer converters and then to add both manganese and silicon to the dephosphorised blown metal in order to cast "semi-killed" ingots of dead-soft quality, to the chemical specification: C, 0·12 per cent. (max.); Mn, 0·30-0·45 per cent.; P + S, 0·050 per cent. (max.). The slag used was taken from one of the duplex basic open-hearth tilting furnaces directly after tapping a dead-soft rimming steel heat of composition similar to that being attempted in this experiment. Both the ferro-silicon and the ferro-manganese were roasted, and added together in a red-hot condition through the dephosphorising slag in the casting ladle. It was found that about 1 lb. of aluminium per ton of steel was required to control the ingot tops and prevent the steel from rising too much in the moulds. The manganese and silicon were evenly distributed throughout the cast, but there was a total loss of 72 per cent. of silicon and 43 per cent. of manganese. It is noteworthy that, whereas the major portion of the iron oxide in the synthetic slag occurred in the form of Fe_2O_3, in the basic open-hearth slag most of the iron oxide was in the form of FeO. Thus they could easily be distinguished.

The quantity of open-hearth slag used was 12½ per cent., notwithstanding which the dephosphorisation was insufficient and the phosphorus in the steel finished on the high side of the chemical specification aimed at, namely, 0·054 per cent., the sulphur being 0·040 per cent. The percentage of phosphorus in the blown metal before dephosphorising was 0·295. Thus it is seen that the dephosphorisation with the basic open-hearth slag was not so intensive as with the Perrin synthetic slag. This, of course, was due to the higher acidity of the furnace slag. The ingots were rolled successfully into 8-in. square blooms and then into 2-in. square billets for the merchant mill. The billets were finally rolled into ⅝-in. diameter rounds in the merchant mill.

*Heat No. P*85. *September* 18, 1937.—The object of this experiment was to dephosphorise two blows from the Bessemer converters; then to add manganese to the dephosphorised blown metal in the casting ladle, and silicon in the moulds, in order to produce semi-killed ingots, suitable for rolling into sheet bar, to the chemical specification: C, 0·11-0·15 per cent. Mn, 0·30-0·50 per cent.; S, 0·050 per cent. (max.); P, 0·05-0·09 per cent. In this experiment, only half the quantity of aluminium (8 oz. per ton of steel) was required, compared with the amount used in heat No. *P*69. The quantity of furnace slag used in this experiment was about 10¾ per cent., compared with 12½ per cent. in heat No. *P*69, and the extent of dephosphorisation was correspondingly less in this than in the former experiment. The phosphorus in the blown metal was 0·288 per cent. and that in the finished steel 0·067 per cent. The manganese efficiency in this experiment was very high, the total loss of this element being only 30 per cent. The ingots were successfully rolled into sheet bar and subsequently, with satisfactory results, into sheets in the sheet mill.

*Heat No. P*100. *November* 10, 1937.—The object of this experiment was to dephosphorise two blows from the Bessemer converters; then to add manganese to the dephosphorised blown metal in the casting ladle, but no silicon at all, in order to produce rimming steel ingots suitable for rolling into merchant mill billets, to the chemical specification: C, 0·10-0·14 per cent.; Mn, 0·30-0·50 per cent.; P + S, 0·050 per cent. (max.). A larger percentage of furnace slag was used in this experiment than in heats Nos. *P* 69 and *P* 85, with the object of keeping the phosphorus below 0·05 per cent. in the finished steel. This was accomplished, but as much as 15 per cent. of furnace slag was employed. The total loss of manganese in this experiment was about 40 per cent. The ingots were successfully rolled into 8-in. square blooms and then into 2-in. square billets for the merchant mill, where they were finally rolled into ⅝-in. diameter rounds with satisfactory results.

It was observed from the results obtained that the dephosphorisation accomplished with basic open-hearth furnace slag was not so intensive as with the Perrin synthetic slag, so that much more of the former slag had to be employed to obtain the same degree of dephosphorisation, owing to the comparatively higher acid content ($SiO_2 + P_2O_5$) of the furnace slag. Nevertheless, it is obvious that 50 per cent. of suitable furnace slag (as low in acids as possible) reconditioned with 50 per cent. of raw materials in the proportions used for making the Perrin synthetic slag, could be efficiently employed for dephosphorising purposes, thus reducing by half the cost of the fluxes. The results of the experiments also showed that, although killed and semi-killed low-carbon steel could be made if required at the expense of a lot of aluminium or other deoxidiser, the slag-dephosphorising direct process was much better and more economically suited for the production of low-carbon rimming steel.

Altogether, in the 100 experimental heats made over a period of two years, more than 3,000 tons of ingots were produced by the slag-dephosphorising direct process, with an average yield of 90·35 per cent. of ingots from blast-furnace iron plus alloy additions; and as the ingots were rolled into various products, mostly with satisfactory mill yields, it was considered that the experimental stage had been passed and sufficient information obtained to ensure that the Perrin process could be operated successfully on a commercial scale in a new plant specially designed for the process. It should also be mentioned that several ingots were sectioned horizontally and longitudinally for a thorough metallurgical examination and for comparison with similar types of ingots made by the basic open-hearth and duplex processes, and it was found that the ingots made by the slag dephosphorisation process were in no way inferior to ingots made by the other processes.

In fact, the results of the experiments were considered to be so satisfactory that the Tata Iron and Steel Company purchased the patent rights for the Perrin process for India and Burma, and are erecting a new plant to operate the process on a site adjacent to the existing duplex plant at Jamshedpur. As only soft steels up to about 0·15 per cent. of carbon can be made direct from the Bessemer converter by the Perrin process, it will be necessary, when producing higher-carbon and alloy steels, to charge the dephosphorised blown metal into a melting furnace (either acid or basic lined) for the addition of the necessary carbon and alloys.*

Perrin-Process Plant; Method of Operation.—Blast-furnace iron of suitable composition (1·10 per cent. to 1·30 per cent. of silicon and 0·30 per cent. to 0·60 per cent. of manganese) will be delivered in 60-ton ladles to the Perrin-process plant and poured into the hot-metal mixer by means of a 100-ton ladle crane. Twenty-four tons of mixer iron will be poured from the hot-metal mixer into a 30-ton ladle supported on an electrically-driven ladle car by which it will be conveyed to one of the 25-ton Bessemer converters. The iron will then be poured into the converter by means of an electrically-operated tilting device.

For the production of low-carbon steel ingots direct from the converter, the iron will be blown until the carbon is about 0·10 per cent. The required weight of dephosphorising slag will be poured from the slag mixer into a casting ladle of 50 tons capacity† supported on a truck, just prior to the converter being turned

* Paper submitted to the Iron and Steel Institute and circulated for written discussion. Abridged.

* For the production of higher-carbon and certain alloy steels, Mr. Perrin has conceived the idea of pouring the dephosphorised blown metal back into the same or into another hot acid converter, the basic slag being thus separated from the treated metal. Silicon and/or manganese are next added to the dephosphorised metal, which is then blown for a few seconds to oxidise the elements added and so to increase the heat of the metal to ensure a sufficiently high casting temperature. After turning down the converter, the required final alloy and carbon additions are made either in the converter or in the casting ladle, according to the chemical specification of the steel required.

† The capacity of the casting ladle is double that necessary for the steel, because of the space required to allow for the rising of the slag in the ladle during the violent dephosphorising reaction.

down. An electric lorry will then place the ladle under the converter, and the blown metal will be poured slowly into the dephosphorising slag from a height of more than 20 ft. Immediately the dephosphorising reaction has subsided, the ladle of slag and metal will be transferred under the chute of one of the ferro-manganese roasting furnaces, and the red-hot lump alloy will be ejected therefrom and will fall down the chute into the casting ladle. The latter will then be conveyed to a position from which it can be hoisted by one of the 100-ton ladle cranes and carried to the casting platform. Five minutes after the addition of the ferro-manganese, the steel will be cast into ingots. Four moulds on stools will be set on one ingot bogie, and, taking the yield at 90 per cent., four ingots each weighing 108 cwt. will be cast.

For the production of higher-carbon and alloy steels, the Bessemer blow will be stopped at a higher carbon content than that required by the chemical specification of the steel. The dephosphorised blown metal containing carbon will be hoisted by one of the 100-ton ladle cranes and poured down a chute into one of the finishing furnaces. Four dephosphorised blows will be required to fill each of the 100-ton open-hearth furnaces, from which the equivalent weight of about two blows will normally be tapped as finished steel into a 50-ton casting ladle, leaving in the furnace approximately half the quantity of metal charged, to which two dephosphorised blows will be added and the process repeated. Ingots of various weights will be cast from acid open-hearth steel in accordance with the requirements of the wheel, tyre and axle plant which is being erected at the same time as the Perrin process plant.

As it will therefore be necessary at times to dephosphorise blown metal containing considerable percentages of carbon, experiments were carried out to ascertain how far this was possible. The results showed that the dephosphorisation of iron, even in the presence of a high percentage of carbon, could be successfully accomplished, provided that there was not too much silicon present in the iron. Thus it is seen how flexible is the slag dephosphorising process.

In summing up the possibilities of the Perrin process as applicable to the conditions at Jamshedpur, any possible value of the used dephosphorising slag as an artificial fertiliser has been ruled out of consideration, owing to its contamination with acid Bessemer slag, and the necessity to use fluorspar to obtain the essential fluidity of the slag. Moreover, it is evident that on account of the loss of phosphorus by volatilisation during blowing, there is an insufficient percentage of this element in the blown metal to yield a sufficiently high P_2O_5 content of the slag.

CATALOGUES.

Outdoor Circuit Breakers.—We have received from Messrs. The English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2, a leaflet describing their class OKD frame-mounted oil circuit breakers for pressures up to 66,000 volts.

Back-Pressure Turbines.—Messrs. The English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2, have sent us a booklet devoted to the application of back-pressure turbines in industries requiring both electric power and low-pressure steam for process work. Typical examples are illustrated and described.

Fire Protection.—We have received from Messrs. Phelps, Beddard, Limited, Georgian House, 139, Sloane-street, London, S.W.1, a leaflet giving particulars of their liquid "Incendex" fire-bomb destroyer. This, it is stated, has the effect of reducing the flame temperature of incendiary bombs from 2,600 deg. F. to 800 deg. F.

Welding for Repair Work.—Messrs. Barimar, Limited, 14-18, Lamb's Conduit-street, Theobald's-road, London, W.C.1, have sent us an illustrated brochure describing their organisation for the welding and machining of broken machinery in all metals and alloys. It is claimed that, in welding cast and malleable iron, the use of their low-temperature process eliminates risk of distortion.

Furnaces for Railway Works.—Messrs. The Incandescent Heat Company, Limited, Cornwall-road, Smethwick, Birmingham, have sent us the first of a series of pamphlets dealing with furnaces for specific industries. This gives a detailed description of the types of furnace suitable for forging, bar and rivet heating, and heat treatment for tool-room and foundry work in railway shops.

Fractional Horse-Power Electric Motors.—Messrs. Higgs Motors, Limited, Witton, Birmingham, 6, have published a number of new catalogue sections. Three of these deal with high-torque fractional horse-power and single-phase motors (type E T H), which are drip-proof and continuously rated to B.S. Specification No. 170-1926; direct-current machines, types W and S.W.; and small tools suitable for direct driving by these motors.

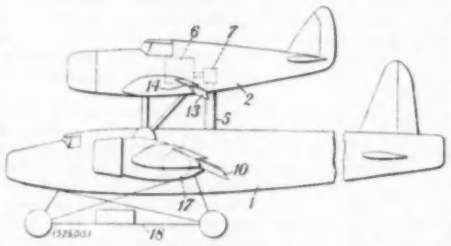
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is given, in each case, after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

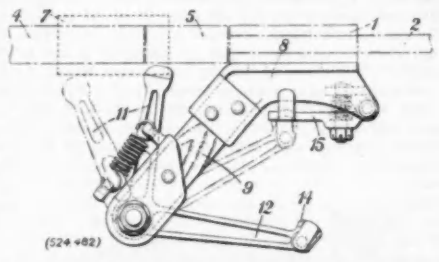
525,015. Composite Aircraft. Vickers-Armstrongs Limited, of Westminster, and D. L. Ellis, of Weybridge. (5 *Figs.*) February 11, 1939.—The invention is an arrangement of a composite aircraft for assisting 'planes during the take-off, and is applicable to flying boats or land 'planes. Its object is to secure the advantages of controlling the boundary-layer air flow over the upper surface of the wings or wing flaps by producing suction or pressure at slots in the wings or flaps, while avoiding the disadvantage of the deadweight of the auxiliary mechanism required to produce the necessary suction or pressure. In the composite unit shown, the main aircraft 1 and the auxiliary aircraft 2 are land 'planes. The auxiliary aircraft is fitted with fixed landing wheels which partly nest in the engine nacelles on the wings of the main aircraft. The aircraft are also connected at a third point by a releasable tube 5 which not only serves to maintain the relative attitudes of the two aircraft but also as a means of connecting the auxiliary engine 6 and blower 7 on the auxiliary aircraft to the communicating passages in the main aircraft which lead



to the slots in the flaps 10 fitted to its wings inboard of the usual ailerons. The blower 7 is also connected to the slots in the upper surfaces of the flaps 13 fitted to the wings of the auxiliary machine inboard of the ailerons 14. Air is sucked by the blower 7 into the slots on the wings of the auxiliary machine and is supplied under pressure to the slots in the wings of the main aircraft. The latter has a retractable undercarriage 17, and the composite aircraft is mounted on a motor-driven take-off trolley 18. Where the main aircraft is a flying boat, the take-off trolley is, of course, not required. The procedure at take-off is as follows:—The unit accelerates as a whole until a speed greater than the stalling speed of the composite aircraft is reached. During this part of the take-off the slots in the wing flaps are in use, and the engine of the trolley, if the main aircraft is a land 'plane, is used to assist in the take-off. In this latter case, when the lift of the composite craft is sufficient, the catches fastening the trolley to the lower machine are released, preferably automatically on a given value of upward pull being exerted on the trolley. After release of the trolley, the composite craft rises slowly and the trolley is brought to rest. The composite craft continues to accelerate until it reaches a speed above the stalling speed of the main aircraft without further use of pressure or suction at the slots. The auxiliary engine operating the blower is then stopped and the two aircraft separate. (*Accepted August* 20, 1940.)

ELECTRICAL APPARATUS.

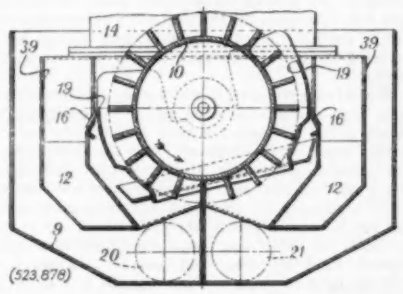
524,482. Trolley-Wire Section Insulator. British Insulated Cables, Limited, of Prescot, London Passenger Transport Board, of Westminster, T. C. Broom, of Huyton, and H. J. Powell, of Liverpool. (2 *Figs.*) January 31, 1939.—The object of the invention is to protect the section insulator from the destructive effect of the arc where a current collector passes from the conductor on to the insulator with the controller in the tram or 'bus in the "on" position. The section insulator consists of a metal end member 1, an insulating guide 4, and a renewable metallic piece 5 bridging the gap between the end piece and the guide. The end of the trolley wire 2 is anchored in a groove in the end piece 1 by set screws. The current collector 7, moves over the section insulator towards the left of the figure. A metal bracket 8 is attached to the end piece 1 and carries an insulating arm 9, on the end of which is pivoted a bell-crank lever. The end of one arm 11 of the lever lies at the side of and near to the point where the collector passes from the conducting path to the insulated runner 4 (full lines in figure). As the collector 7 passes this point it makes contact with the arm and carries it forward. The second arm 12 carries a contact 14 at its end and as the first arm is carried forward by the current collector 7, the contact 14 is moved to engage a fixed contact 15 on the metal bracket. The engagement of the two contacts



occurs before the current collector 7 breaks contact. There is thus formed an auxiliary path from the current collector to the trolley wire. Thus, during the first part of the movement of the collector over the insulator 4, after leaving the metal piece 5, no arc occurs. When the collector becomes disengaged from the arm 11, the bell-crank lever, which is spring-loaded, flies back to its initial position. Thus the auxiliary path is rapidly broken at two places, at each of which an arc is drawn out. By making the arm 12 longer than the arm 11, and by providing the contacts 14 and 15 with arcing horns, the separation at these contacts is made more rapid. (*Accepted August* 7, 1940.)

MISCELLANEOUS.

523,878. Sewage-Treatment Plant. James Mills and Company (Engineers), Limited, of Heywood, and J. F. Bolton, of Heywood. (6 *Figs.*) January 26, 1939.—The invention is a traversible carriage for treating liquid sewage. A central feed trough extends for the length of the filter bed and into it the "water" is led. It supports rails on which run the wheels of the traversible carriage, and on each side of the latter are supported, in pendant frames, the water-wheel chambers 9. Each water-wheel chamber contains the reversible water-wheel 10, on each side of which there is a weir box 12 closed at the bottom and a little longer than the water-wheel. The inner ends of these weir boxes communicate with one leg of a syphon pipe 14 which is suspended from the chassis with its common central leg dipping into the water in the feed trough. Each weir box has a strip of rubber 16 with which co-operates a movable weir structure extending along each side of the wheel and having on each side a weir 19. The structure can be rocked to raise one weir and lower the other, or vice versa, to



permit the flow of water from only one weir box into the water-wheel. Water escapes from the water-wheel into the bottom of the chamber 9, which is divided into two compartments served, respectively, by sprinkler pipes 20, 21. The carriage is traversed by the water-wheels which are geared to the running wheels. The reversing of the water-wheels is automatic, the weir structure being tipped by a reversing lever which is tripped by fixed abutments beside the track. The water syphoned from the trough flows into both weir boxes but, owing to the position of the weir structure, it can only flow over the lower weir to rotate the water-wheels and then pass into one of the sprinkler pipes. When the carriage reaches the end of its traverse the reversing lever is tripped and the weir structure is rocked to raise the lower weir and lower the raised one, and so the rotation of the water-wheel is reversed. Each weir box is provided with a back weir 39, a little higher than the rubber packing strip, so that when an extra large flow of water occurs, the surplus can escape over these back weirs into the chamber 9 and so to both sprinkler pipes, with the result that the surplus is rapidly disposed of. (*Accepted July* 24, 1940.)